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PHYSICS.—*On research and education—in fluid dynamics.*[1]

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"Many of the physical sciences seem to have abandoned the laboratory for students." This observation was made by G. E. Erikson of Harvard University in I. B. Cohen's and F. G. Watson's *General education in science* (1952). Another interesting remark is one by S. J. French of Colgate University that "general education is only an improved version of liberal education." Both these statements take us back to the Academy which Plato conducted for 41 years in the Athenian grove honoring the Greek hero Akademos. The disciples who gathered about him there outside the city were eager to learn, not special information peculiar to observed phenomena, but rather general principles underlying universal knowledge.[2] Two academic emphases have had an influence upon education long after the closing of the Academy by Justinian nine centuries later. Inasmuch as Plato was not interested in the imperfect material triangles that one observes, wooden triangles, metal triangles, etc., but rather in the idea of a perfect triangle, his followers were intent primarily upon contemplating this thoughtful world. The Greeks had a word for such an attitude, viz., theory (from the same root as the Greek word for theatre—meaning, to view). Aristotle later contrasted this point of view with the practical (meaning, to do) business of doing. Consequently, there has been a persistent trend in traditional humanistic education to keep it divorced from progressive scientific research about things.

On the other hand, the enterprise of scientific research was initially disassociated from education. The classic document along this line was Francis Bacon's *New Atlantis*, published incomplete in the year of his death, 1626.[3] You may recall that in his *Timaeus* Plato mentions a lost island of Atlantis somewhere west of Gibraltar. Regarding the discovery of America as virtually that of Atlantis, Bacon visualizes a new Atlantis some place in the Pacific west of America. In this book, he describes an ideal research institute, Salomon's House, which had the following objective: "The end of our foundation is the knowledge of causes and secret motions of things." His proposal in many respects is quite novel, even modern.

Salomon's House contained specialized facilities for various types of investigations. There were deep caves for exploring phenomena beneath the earth, as well as high towers on mountains for observing meteorological phenomena. There was a special laboratory for high-temperature investigations, one for optics, one for acoustics. A special room was provided for the artificial production of rain. One room contained primarily engines, including some for ordnance. Finally, there was a mathematical room filled with appropriate instruments. It was recognized that the proper utilization of these facilities would requisition the entire time of the workers.

Novices and apprentices were to be differentiated from what we nowadays call professional personnel, 36 fellows in all, grouped as follows: 12 merchants of light who roamed about the earth in search of

[1] After-dinner address, Fluid Dynamics Division, American Physical Society, July 2, 1953, Pennsylvania State College.

[2] SARTON, G. *History of science*. Cambridge, 1952.

[3] *Famous new deals of history*. New York, 1935.

observed data; 3 deprepators who sought such data in books; 3 individuals who collected data from current experiments; 3 pioneers who collected data from new experiments, and 3 compilers who classified and tabulated all these data. In addition, there were 3 benefactors whose primary function was to determine how to use all the results; 3 planners of new experiments, 3 others who performed these experiments and reported on them, and finally 3 who interpreted all the discoveries thus made.

It is to Bacon's credit that he sensed the importance of a cooperative enterprise of specialists having available unusual equipment and books. Although Bacon himself was not a scientist and failed even to recognize the outstanding scientists of his day, such as Galileo, Gilbert, and Harvey, nevertheless, he successfully sowed and propagated the concept of a research organization. The *New Atlantis* went through ten editions before 1670. Its influence may be seen in that the frontispiece of the first (1667) *History of the Royal Society* by Thomas Sprat has as a central figure the bust of Charles II, on one side the President of the Royal Society, and on the other side, Francis Bacon himself.[4]

Another description of a utopian learned society, this time with satirical intent, appeared exactly 100 years later (1726) in Jonathan Swift's *Gulliver's Travels*. In *A Voyage to Laputa* (Part 3), attention is called to the flying island Balnibarbi with its Academy of Projectors in Lagado, the metropolis. The academy had more than 500 rooms, each with more than one projector (in charge of a project). A comment by the guide, a former projector, is pertinent: "The only inconvenience is that none of these projects are yet brought to perfection and in the meantime the whole country lies miserably waste, the houses in ruins, and the people without food and clothes." To cite a celebrated instance, for eight years one man had been "extracting sunbeams out of cucumbers, which were to be put into vials hermetically sealed and let out to warm the air in raw inclement summers." An old established custom was the begging by the projectors for funds to carry on their work. On the other side of the academy, there were "projectors in speculative learning," such as a universal artist who had been for 30 years employing his thoughts for the improvement of life.

Meanwhile, the serious development of scientific interests began to necessitate special funds for apparatus. Up to the middle of the seventeenth century, support for scientific investigations had been largely the personal concern of individuals. We recall that Archimedes had been supported by King Hieron of Syracuse. Galileo later spent much effort to obtain his final appointment at the court of the Grand Duke of Tuscany. He was succeeded in his position there by Evangelista Torricelli. Occasionally, the church was found supporting unusual priests, such as Edmé Marriotte. It is noteworthy that in all these instances the individuals apparently had adequate leisure and freedom to carry on their own investigations in addition to fulfilling certain obligations of a more applied or engineering character. Now and then a person like Robert Boyle had sufficient wealth in his own right to carry out his researches. Otto von Guericke, the mayor of Magdeburg, was apparently able to use $20,000 of available funds for his experiment with the famous hemispheres.

The increased interest in science in the early 17th century made the acquisition of funds of paramount importance. In view of the Pope's condemnation of Galileo's opinions, it is not surprising that scientific research was little supported by the universities of that day. Academies of science, therefore, were organized primarily for this purpose.[5] An early society was the Accademia dei Lincei in Rome from 1600 to 1630; it included Galileo in its membership. The more active Accademia del Cimento of Florence (1657–1667) was the first organized scientific academy; it was made up largely of members of universities in the vicinity. They pursued a careful program of measurements guided by the motto, "Probando e Reprobando," while cautiously avoiding any theoretical interpretations in

[4] STIMSON, D. *Scientists and amateurs—a history of the Royal Society*. New York, 1949.

[5] ORNSTEIN, M. *The role of scientific societies in the seventeenth century*, ed. 3. Chicago, 1938.

view of Galileo's indiscretions. In 1662, the second year of the Stuart Restoration, Charles II founded the Royal Society in England, essentially a group of amateurs of science. The French Académie des Sciences was established in 1666 by Louis XIV. Including laboratory work, it was generally supported and regulated by the government. Each academician was asked to submit a program of his own work. Following Bacon, Christian Huygens organized cooperative research for compiling and amassing facts. For example, there were two scientific expeditions: one to Uranienburg and one to Cayenne, as well as two well-known cooperative projects, a history of animals and a history of plants. The Berlin Academy was founded in 1700 through Gottfried W. Leibniz by Frederick the Great.

It is significant that even when outstanding scientific research emanated from a university little stimulation might be given a man like Isaac Newton by his colleagues there. Indeed, the Cartesian physics which Newton himself had disproved was still taught at his own University of Cambridge in 1718 long after he had left. It is noteworthy also that the Royal Society, whose charter originally permitted the forming of a college, definitely rejected such an institution as not being conducive to research in view of its primary obligation to teaching. (Abraham Cowley actually proposed the support of such a college from the profits out of resulting scientific inventions.)

The scientific academies did not pursue their objectives without popular ridicule. In "The Clouds" Aristophanes had long ago poked fun at Socrates in his phronisterium (thinking house). There Socrates is found suspended in a basket. In reply to a question as to what he was doing Socrates said, "I walk on air and contemplate the sun."[6] Charles II himself is credited with having slyly proposed to the members of the Royal Society at their charter banquet a question as to why a pail of water weighs the same when two live fish are put into it. After considerable discussion on this subject by the members he admitted knowing that such a pail actually weighs more. He is said to have laughed also at the professors at Gresham College who weighed air. In 1673, the poet laureate, Thomas Shadwell, culled data from the publications of the Royal Society and wrote a play called "The Virtuoso." The leading character was Sir Nicholas Gimcrack, who suspended himself on a rope from the ceiling and imitated the motions of a frantic frog swimming in a nearby bowl of water. When asked why he did not learn swimming by immersing himself in water, Sir Nicholas replied, "I content myself on the speculative part of swimming. . . . I care not for the practice." Later critics were Samuel Butler, Joseph Addison, and Richard Steele. The private views of scientists will always be open to public criticism by non-scientists.

Thus we see that as traditional education had developed independently of research, so cooperative research originated independently of education. It is not surprising that these two merged later into research *and* education.

The first such program, strangely enough, was organized by Aristotle.[7] After studying with Plato, he started a school outside Athens on the side of town opposite the Academy in a grove sacred to Apollo Lyceius. For 13 years, he was the head of this peripatetic Lyceum, which combined formal lectures with organized research, both personal and collective. Those of us who are physicists are prone to pass over Aristotle's contributions to research because of certain flagrant errors in his physics which retarded its growth when scholasticism later popularized Aristotelianism. One of the prominent errors was based on a false interpretation of observations in fluid dynamics. For example, looking at matter in motion Aristotle had perceived that the greater the force applied to a body at rest the greater the speed the body acquires and that the greater the resistance of the medium traversed the less the speed the body develops. One might say that speed in this instance is roughly proportional to the ratio of the initiating force and the resisting force. On this basis, a vacuum, which has zero resistance, would produce an infinite speed.

[6] COOPER, L. *Fifteen Greek plays*. Oxford, 1950.

[7] SARTON, G. *Op. cit.*

Believing that so great a speed is impossible, Aristotle rejected the underlying assumption, namely, the concept of a vacuum. The phrase, "Nature abhors a vacuum," became proverbial. Galileo, on the other hand, reviving this rejected idea of a vacuum, concluded correctly that speed in this case is proportional to time (Aristotle had erroneously decided that speed is proportional to distance). Aristotle, however, was successful in other observations of phenomena such as those associated with meteorology.

Isolated cases of combined research and education are found in the 17th and 18th centuries. For example, Galileo achieved his most outstanding scientific successes while he was at Venice's University of Padua, prior to 1610, when he moved to Florence. It was in the earlier period that he conducted fundamental investigations on his two new sciences (motion, including that of projectiles, and the strength of materials, including the power of a vacuum). It was in these years, too, that he invented a thermoscope, as well as the telescope which he used in discovering the moons of Jupiter early in 1610. Daniel Bernoulli participated in the St. Petersburg Academy for 8 years, but he published his famous book on "Hydrodynamica" during his later tenure as professor of physics at the University of Basle. An interesting development was the Collegium Curiosum sive Experimentale at Altdorf University. Christopher Sturm, the professor of physics and mathematics there, set up a laboratory with instruments for teaching his university students in his home. He is said to have trained many skilled experimenters. Two volumes of experiments were published and subsequently served as a textbook of experimental physics.

The culmination of these isolated instances and the initiation of a new era occurred in the establishment of the École Polytechnique in 1797, a byproduct of the French Revolution. The first professor in Mathematics was J. L. Lagrange who had spent most of his life engaged in research at the Berlin Academy although earlier in his life he had attempted to establish a research institute in connection with his teaching at the Turin Royal Artillery School. It is worth noting that Lagrange had been recommended by Laplace who had once examined a pupil by the name of Napoleon in the École Militaire. The mid-nineteenth century became replete with university posts filled by men who combined research and education interests. We naturally think of pioneers in fluid dynamics such as G. G. Stokes at Cambridge, W. Thomson, Lord Kelvin, at Glasgow, H. von Helmholtz at Bonn and Heidelberg, and L. Prandtl at Göttingen. Nowadays such activity is not unusual.

In conclusion, I should like to say a few words about some of the motivating principles underlying the National Science Foundation's program in fluid dynamics. It is rather significant that the 1950 Act which established the Foundation stresses "the promotion of basic research and education in the sciences." Not education per se, not research per se, but rather research *and* education. Some of us have begun to feel that the most important word here is the connective, "and".

We find our minds meditating on the concept of the great scientist-scholar. You know, and I know, individuals who have been great teachers despite their lack of competence in research. We have known also great research people who have been impossible as teachers. The average teacher, however, would undoubtedly be a better teacher because of some research and the average researcher would probably be better in his research because of some teaching. In any event, the great scientist-scholar must be motivated by superior intellectual curiosity whether he engages primarily in research at a university or engages mostly in teaching at a college. I am reminded of a statement made by Prof. A. M. Tyndall of the University of Bristol when he was president of Section A of the British Association for the Advancement of Science in 1952. He quoted from Prof. C. F. Powell's Nobel Prize citation: "His special claim to consideration is, in my view, the fact that he has shown that discoveries of fundamental importance can still be made with the simplest apparatus." Powell had used a photographic emulsion to record the tracks of charged particles. Sometimes in our awareness of the increasing importance of

large-scale facilities in pushing back the frontiers of science, we forget that behind the facilities there must be an individual, and that behind the individual there must be an idea. The Foundation is interested in supporting such individuals with ideas. The Foundation has no preconceived notion as to whether these individuals will be found primarily in the north or the south, in the east or the west; in university or college; whether they will belong predominantly to any one race or creed, to any one nation or class.

Another fertile concept is that of the great university or college. One readily recognizes three areas of influence of any modern educational institution. Initially there is the fundamental concept of teaching. Developing from this central motivation is the sensitizing region of basic research, while spreading from this stimulating field is the outgrowth of public service, including applied research and development. It does seem, however, that the third function has often overbalanced the other two which are the proper domain of an educational institution (except possibly in times of national emergency). Assuming that a college will be primarily concerned with teaching, that a university will be primarily concerned with research, and that both have some responsibility for public service, we believe the urgent need today to be the establishing of more research in colleges and the shifting of emphasis from applied research to basic research in universities, at least insofar as fluid dynamics is concerned.

In pursuit of these ideals of the American scientist-scholar in the American college and university, the National Science Foundation is genuinely desirous of assisting individuals interested in *research and education* in fluid dynamics.

MATHEMATICS.—*A lower limit on the number of hypergroups of a given order.* HOWARD H. CAMPAIGNE.

An outstanding problem in groups is to determine the number of distinct groups of a given finite order n. It is of some interest to study this problem with the group axioms relaxed. In this paper a lower bound for the number of hypergroups of order n is shown to be $8 \times 11^{n-2}$. An upper bound can readily be found.

A hypergroup is a set H of elements satisfying three postulates.

1. If a and b are any two elements of H, then there is associated with this ordered pair a subset of H, not necessarily proper, called the product ab.

If A and B are subsets of H, then their product AB is defined to be the union of all ab, for a in A and b in B. If O is the null set, then $OB = O = BO$.

2. If a, b, and c are elements of H, then $a(bc) = (ab)c$.

3. If a and b are any elements of H, then there are elements x and y, not necessarily unique, such that b is in each of the sets ax and ya.

Although the product ab is not necessarily proper it cannot be void.

In a hypergroup of order n there are $2^n - 1$ subsets which might appear as products. There are n^2 products to be defined. Therefore there cannot be more than $(2^n - 1)^{n^2}$ hypergroups of order n, and a crude upper limit is established.

In order to establish a lower bound we will give rules for constructing a number of distinct hypergroups. This will be done by induction, that is, from each hypergroup of order n will be constructed 11 of order $n + 1$, which will be shown to be distinct. The complete proof is tedious with special cases, so only an outline will be given here.

Our problem then is to adjoin an element a to a hypergroup H in such a way as to form a new hypergroup G. Let h_1, h_2, $\cdots$ be elements of H, and $h_i \cdot h_j$ mean a product in H, while $h_i h_j$ means a product in G. First define $h_i h_j = h_i \cdot h_j$. Then for a general hypergroup H exhaustive trials show that there are only six ways of defining the products ah_i, a^2, and $h_i a$ so that G satisfies the three postulates. These are listed below in tabular form.

TYPE 1

rule	ah_i	a^2	h_ia
1	a	H	a
2	a	G	a
3	G	a	G
4	G	G	G
5	a	G	G
6	G	G	a

There is another possibility for h_ih_j, that is to have the element a adjoined to it, that is, define $h_ih_j = h_i \cdot h_j \cup a$. Again there are six ways of defining the remaining products.

TYPE 2

rule	ah_i	a^2	h_ia
7	G	a	G
8	H	a	H
9	G	H	G
10	G	G	G
11	H	a	G
12	G	a	H

There is a third type of rule conceivable for which some products h_ih_j contain a and others do not. If there is such a rule depending in no way on the hypergroup H then it must apply to groups as well as to hypergroups. Examining the application of the rule to a group it appears that if $xy = x \cdot y \cup a$, where $x \cdot y = w$, then a cannot be adjoined to any product $r \cdot s \neq w$. Furthermore w and a are inseparable, for if $t \cdot s = w$, then $ts = w \cup a$ is a necessary consequence.

Now turn our attention to the hypergroup T which has for every pair of elements $t_i \cdot t_j = T$. If a is always associated with some element then it is in every product t_it_j. For T then the rule is indistinguishable from a type 2 rule, and therefore useless to us. Thus only the twelve rules tabulated above are possible.

In order to show that these extensions are distinct we will need certain auxiliary theory, which we outline here. Let $d(h_ih_j)$ be the number of distinct elements in the product h_ih_j. Then the unordered set of n^2 numbers $D(H) = \{d(h_ih_j)\}$, where h_i and h_j run through the hypergroup H, is an invariant under isomorphism. A necessary and sufficient condition that H be a group is that $D(H)$ consist of all 1's. The set $S(H) = \{d(h^2)\}$ of n numbers is also an invariant. The set $I_h = \{d(hx)\}$ where x ranges through the n values of H, is also an invariant. By convention $d(h^2)$ is always the last number in this set. Similarly $I_h = \{d(xh)\}$. Furthermore any symmetric function of one of these sets is an invariant. By means of these invariants we will show the various extensions of H to be isomorphically distinct.

Lemma 1. Given any two nonisomorphic hypergroups H and K of order n, with H extended by a to hypergroup G, and K extended by b to hypergroup J. Then G and J are not isomorphic provided rules 9 and 10 are not both used.

Outline of the proof. Suppose that the rule used on K has a rule number not less than that used on H. This is convenient and quite general.

Now suppose the contrary of the lemma, that G is isomorphic to J under a mapping $f(G) = J$. Then $f(a) \neq b$, for otherwise $f(H) = K$, contrary to hypothesis.

Observe that $d(h_ih_j) \leq n$ if G is formed by a rule of type 1 and $d(h_ih_j) \geq 2$ if the rule is of type 2. A complete proof would require the consideration of each rule applied to each of the hypergroups H and K. In order to shorten the exposition we will do only a few rules on H.

Rules 7, 8, 11, and 12. In G we have $d(a^2) = n + 1$, which implies that J, if it is isomorphic to G, was not formed by a rule of type 2. Therefore these cases are impossible.

Rule 9. Hypergroup K can have rules 9, 10, 11, or 12 applied to it. If rules 11 or 12 then $d(b^2) = 1$ in J, and G cannot be isomorphic to J. If rule 9 is applied to K to form J, and if G is isomorphic to J, $f(G) = J$, then there is an automorphism t of J defined as follows. Let $t(b) = f(a)$, and $tf(a) = b$. If $f(a) \neq k \neq b$ then define $t(k) = k$. The mapping $tf(G) = J$ is a second isomorphism of G to J with $tf(a) = b$. Therefore $tf(H) = K$, contradicting the hypothesis. But J can be formed from K by rule 10. In fact, if a hypergroup A is extended by rules 9 and 10 to give hypergroups B and C, respectively, and if these are extended by rules 10 and 9 to give B' and C' respectively, then B' and C' will be isomorphic, but B and C will not be.

By similar arguments all pairs of rules can be excluded except 9 and 10, and this will establish lemma 1.

There remains the possibility that the same hypergroup H could be extended by two different rules to isomorphic results.

Lemma 2. If H of order greater than 1 is extended by two different rules to hypergroups F and G, then F and G are not isomorphic.

Outline of proof: Suppose F isomorphic to G under the mapping m. We have $F = H \cup a$ and $G = H \cup b$, and $F = m(G)$. Evidently $a \neq m(b)$ by the definitions of the various rules. Let $p = p(H)$ be the sum of all the numbers in $D = \{d(h_i h_j)\}$ over H. Then $p(G)$ is given for the 12 rules by the following table.

rule	$p(G)$
1	$p + 3n$
2	$p + 3n + 1$
3	$p + 2n^2 + 2n + 1$
4	$p + 2n^2 + 3n + 1$
5 and 6	$p + n^2 + 3n + 1$
7	$p + 3n^2 + 2n + 1$
8	$p + 3n^2 + 1$
9	$p + 3n^2 + 3n$
10	$p + 3n^2 + 3n + 1$
11 and 12	$p + 3n^2 + n + 1$

It is evident that in general no two of these are equal. There may be specific values of n for which equality occurs; we will take them up later.

By rule 5 we have $\overline{I}_a = \{n + 1, n + 1, \cdots, n + 1\}$. By rule 6 there is no element having this property. By rule 11 we have $d(a^2) = 1$, and by rule 12 there is no element g except b for which $d(g^2) = 1$.

The lemma has now been proved except for those values of n mentioned above. These exceptional values are $n = 2$ and 3. For $n = 2$ rules 3 and 8 might conceivably give isomorphic results. But if $s(H)$ is defined to be the sum of all $d(h^2)$, we see that $s(F) - s(G) = n = 2$. Thus the results are not isomorphic. For $n = 2$ rules 4 and 11 or 12 might give isomorphic results. But by rule 11 we have $I_b = \{2, 2, 1\}$, and by rule 4 every I_h contains a 3. For rules 4 and 12 we have $\overline{I}_b$ and $\overline{I}_h$ similarly inconsistent.

For $n = 3$ rules 4 and 8 might give isomorphic results. By rule 8 we have $I_b = \{3, 3, 3, 1\}$, and by rule 4 there is a 4 in I_h. This completes the proof of the lemma.

For $n = 1$ we can write out all the extensions. There are exactly eight hypergroups of order 2, and these are all given by our twelve rules applied to the identity group.

Theorem: The number of distinct hypergroups of order $n + 1$ is at least 11 times the number of order n, for $n \geq 2$.

Because rules 9 and 10 are exceptional we discard one of them. Then the theorem follows.

Theorem: The number of hypergroups of order $n \geq 3$ is greater than $8 \times 11^{n-2}$.

For this many could be constructed by starting with the hypergroups of order 2 and iterating the constructions. The groups of order $n \geq 3$ are not among these, and they bring the total above $8 \times 11^{n-2}$.

Other ways of extending a hypergroup can be invented, such as adjoining one hypergroup to another, or adjoining several elements simultaneously. But to prove the results isomorphically distinct by the methods used here is too formidable to undertake lightly.

PALEOBOTANY.—*A Permian* Discinites *cone.*[1] SERGIUS H. MAMAY, U. S. Geological Survey. (Communicated by James Stark Williams.)

The Paleozoic plant collections in the United States National Museum include an abundance of interesting Permian material from the southwestern United States. Aside from a few small lots, these collections were made by the late David White and C. B. Read, both of the U. S. Geological Survey. With the exception of White's description of *Gigantopteris americana* (1912) and Darrah's paper on *Tingia* (1938), accounts of these floras have not been published.

Recently the writer's curatorial efforts have primarily concerned these collections. During the course of this preliminary survey, conducted with the purpose of undertaking a long-range investigation of the Permian floras of the American Southwest, several unusual floristic features have been noted; one of these is the presence of *Discinites*, a genus not previously known to occur in strata as young as the lower Permian. Four fragmentary specimens (U.S.N.M. numbers

[1] Publication authorized by the Director, U. S. Geological Survey.

40626–40629) were found, representing two localities in north-central Texas.

Specimen no. 40626 bears the U.S.G.S. locality number 8959. This collection was made by C. B. Read and H. W. Ervin in October 1940. Their collecting label reads: "Upper part of Belle Plains formation in e. central part of Emily Irish Grant, south side of Salt Fork of Brazos River, Baylor County, Texas. 16 to 16½ miles scaled due southeast of Seymour, Texas."

Specimens 40627–40629 bear the U.S.G.S. locality number 8877; these were among collections made by David White in 1910. According to White (1912, p. 495), this locality is at: "... the bank of the stream at the crossing of the old road, one-fourth mile south of the ford of Little Wichita River, 4 miles southeast of Fulda, a station in Baylor County." Material from this locality was the source of White's paper (1912) dealing with *Gigantopteris americana;* this exposure, as well as that from which the C. B. Read collection was made, occurs in beds of the Wichita group, which is regarded as lower Permian (Moore, 1949).

Discinites is a genus of Paleozoic cones that differ from other contemporaneous strobiloid fructifications in that they possess the following unique combination of structural features:

1. The cones are verticillate, with a disc of laterally fused sporophylls arising from each node.

2. The upper surface of each disc is covered by numerous, closely set, apparently sessile sporangia.

3. The cones are heterosporous, both mega- and microsporangia being produced in the same whorl.

Several species of *Discinites* are known, all of pre-Permian age. The genotypic species, *D. bohemicus*, was reported from the Westphalian C of Czechoslovakia by K. Feistmantel, founder of the genus, in 1879. Subsequently several additions to the genus were made from the Westphalian of Czechoslovakia. These are: *D. major* Nemejc (1937), *D. raconensis* Nemejc (1941), *D. Hlizae* Nemejc (1941), and three additional entities simply referred to by Nemejc (1941) as *D.* spp. *1*, *2*, and *3*.

The Westphalian of Holland has produced one additional species, *D. Jongmansii* Hirmir (1940), and the known geographic distribution of the genus has been extended to the United States by Arnold's (1949) report of *D. delectus* (Arnold) Arnold and *D. Jongmansii* among the Pennsylvanian plants described in his flora of the Michigan coal basin.

DESCRIPTION OF THE SPECIMENS

The transverse aspect of the cone is shown by specimen 40626, which consists of the compression and counterpart of a single sporophyllar disc, compressed parallel to its upper surface. This disc, with its attached sporangia, is shown in figures 1 and 2. The specimen is in a matrix of blue-gray, fine-grained shale; there is little carbonaceous material left in the specimen, parts of its surface having been replaced by a powdery white calcite deposit. However, such features as the margins of the disc, position of the cone axis, and the size and distribution of the sporangia may be made out reasonably well.

The circular sporophyllar disc is about 2.5 cm in diameter, exclusive of the marginal teeth; at one side of the specimen the margin is partly buried in the matrix (broken line at the right of Fig. 2). At the center of the disc there is a slight elevation, which represents the cone axis (Fig. 2, *a*). This is a rather stout axis, measuring about 4 mm in diameter.

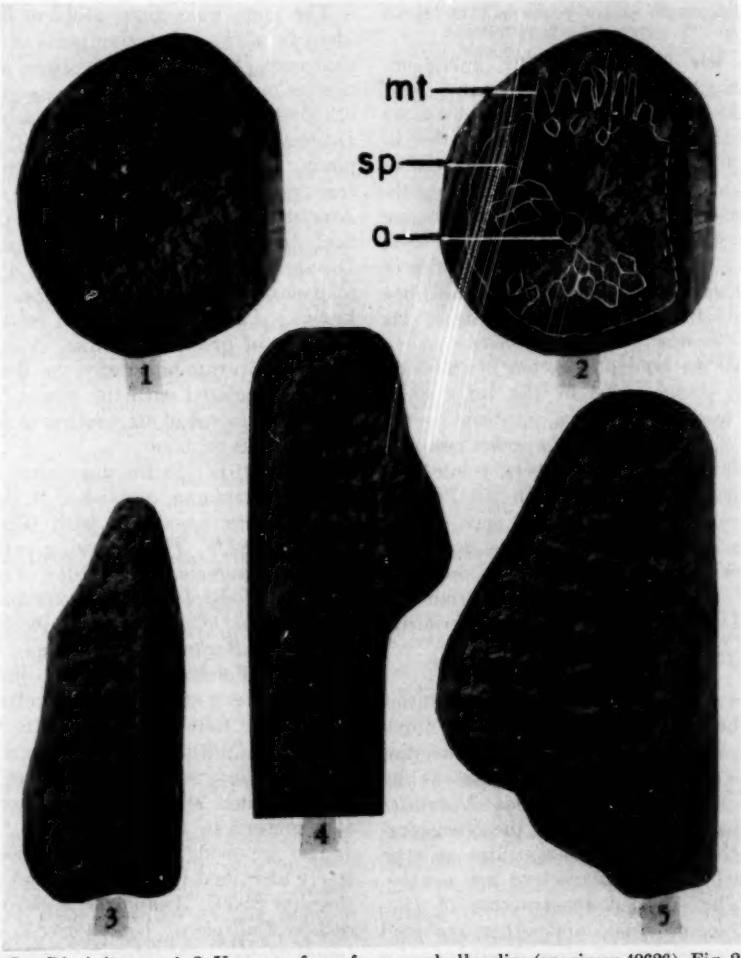
Part of the margin is completely flattened; in this part several separate marginal teeth may be seen (Fig. 2, mt). The teeth are 4 to 6 mm long and about 1.5 mm wide at their bases, tapering gently to blunt tips. Judging from their size in relation to the diameter of the disc, there were probably 40 or 50 teeth to the margin of the disc.

Aside from the central portion that represents the cone axis, the surface of the disc is covered by a pattern of closely fitting diamond-shaped marks that doubtless represent the sporangia (fig. 2, sp). They are slightly elongate in the radial direction, reaching 3 mm in that dimension. There is no evidence to indicate the method of sporangial attachment to the disc; nor can the differences between mega- and microsporangia be made out, if both kinds were present in this whorl. The sporangia cannot be accurately counted, but, judging from the areas where they can be counted and the sizes of these areas in relation to the total area of the disc, probably 100 to 150 sporangia were attached to this disc.

The size of this specimen and its attached sporangia compares closely with that of the specimen designated as *Discinites* sp. *1* by Nemejc (1941, fig 1). In the shape of the sporangia, however, it compares more closely with *D. bohemicus* (cf. Nemejc, 1937, figure 2), and in the toothed margin of its sporophyllar disc, the specimen recalls *D. Jongmansii* (Hirmer, 1940, figs. 1–10).

The remainder of the material consists of three fragmentary specimens (40627–40629) that clearly present the longitudinal aspect of *Discinites* (figs. 3–5). These are all from locality no. 8877 and are preserved in a rather coarse-grained, light-brown, sandy shale.

The largest fragment (specimen 40629) is about 4.5 cm long and 2 cm wide (fig. 5). It contains parts of 11 consecutive discs, each of whose closely arranged sporangia may be seen. The discs are about 2 mm apart.



FIGS. 1–5.—*Discinites* sp.: 1, 2, Upper surface of a sporophyllar disc (specimen 40626), Fig. 2 retouched with white ink to show more clearly the marginal teeth (mt), the sporangia (sp), and the cone axis (a); 3, Fragment of a longitudinally compressed specimen (no. 40627) showing parts of nine successive whorls; 4, Fragment of a longitudinally compressed specimen (no. 40628) showing parts of 13 successive whorls; 5, Fragment of a longitudinally compressed specimen (no. 40629) showing parts of 11 successive whorls. Faint impressions of several of the upturned marginal teeth of the sporophyllar discs may be seen at the right. (All figures ×1.5.)

The sporangia appear to be in their natural erect positions, apparently having undergone little compaction during the process of preservation. They average about 2 mm in height and 1 mm in width as seen on their tangential surfaces (Figs. 3–5). There is little organic matter left in these specimens, and it was therefore impossible to isolate spores for comparison with those of previously described *Discinites* specimens. As in specimen 40626, there is no evidence concerning the relative distribution of micro- and megasporangia or the mode of attachment to the discs.

At one side of specimen 40629, several upturned marginal teeth of the discs may be seen (Fig. 5). As far as can be determined, these are approximately the same size as those seen in specimen 40626 (Figs. 1, 2), and they appear to demonstrate the natural positions of the teeth. The specimens shown in Figs. 3, 4, and 5 compare favorably with *D. delectus* (cf. Arnold, 1949, pl. 28, fig. 6). However, there is no suggestion of pairing of the sporangia, as originally described by Arnold (1944) when he first assigned his specimens to the genus *Bowmanites*.

Although the generic characters of *Discinites* are clearly demonstrated by the Texas specimens, a specific designation for them is not offered here, because of their imperfect preservation. There are close resemblances, pointed out in previous paragraphs, between the Permian specimens and certain of the older ones, but the differences in both geographic and stratigraphic occurrences present a strong likelihood that additional material may eventually warrant the erection of a new species for the Texas specimens.

DISCUSSION

The vexing problem of natural affinities of detached reproductive organs of fossil plants presents itself again in connection with this occurrence of *Discinites*. While there is some agreement that *Discinites* is most probably referable to the Noeggerathiales, the broader relationships of the Noeggerathiales in themselves are controversial. The whorled construction of *Discinites*, *Tingiostachya*, and other included genera suggests a sphenopsid alliance for this group, and although this feature alone is insufficient evidence for an incontestable assignment of the Noeggerathiales to the Sphenopsida, such an interpretation seems preferable to Hirmer's (1940) inclusion of the Noeggerathiineae within the Filicales. A full discussion of the systematic position of this group of plants is quite beyond the scope of this paper; however, it should be pointed out in passing that the reference of these plants—with their *strobiloid* fructifications—to the Filicales represents a radical and, in the writer's opinion, unwarranted departure from the established tenets of fern morphology and systematics.

The more immediate problem lies in the identity of the vegetative parts of the plant that bore *Discinites*. On the basis of association alone, Nemejc (1937) and Hirmer (1940) have suggested the probability that *Discinites* is the fructification of the same plant that bore *Palaeopteridium* foliage; this association has also been noted by Arnold (1949) in the flora of the Michigan coal basin. This Permian occurrence of *Discinites* throws doubt on such a proposed relationship, however, for as far as presently known, *Palaeopteridium* is restricted to horizons of pre-Permian age. It is, then, of interest to examine briefly the floristic elements associated with the Texas *Discinites*, with the purpose of attempting to shed some light on this problem.

White (1912), in his discussion of *Gigantopteris americana*, published a list of the plant genera associated with *Gigantopteris* (locality 8877). The following genera were noted: *Annularia*, *Araucarites*, *Aspidiopsis*, *Cordaites*, *Diplothmema*, *Gomphostrobus*, *Neuropteris*, *Odontopteris*, *Pecopteris*, *Poacordaites*, *Sigillaria*, *Sphenophyllum*, *Taeniopteris*, and *Walchia*.

The writer's survey of this collection has added the following genera to this list: *Aphlebia*, *Callipteris*, *Daubreeia*, *Lebachia*, *Lepidophyllum*, and *Odontopteris*. A few undetermined strobiloid fructifications are also present in the flora.

The following genera have been tentatively identified in the C. B. Read collection (locality 8959): *Annularia*, *Aphlebia*, *Araucarites*, *Callipteris*, *Gigantopteris*, *Lebachia*, *Odontopteris*, *Pecopteris*, *Sphenophyllum*, *Taeniopteris*, and *Tingia*. This flora is essentially the same as that of White's collection in generic composition; the most outstanding difference between the two lies in the

apparent absence of *Tingia* from the White collection; this genus is very abundant in the Read collection.[2]

Thus far, then, *Tingia* is the only vegetative element of supposedly noeggerathialean affinity known in these two floras; if one were to attempt to establish a fructification-foliage alliance for *Discinites* on the basis of association alone, *Tingia* might well appear to be the logical foliage genus in these assemblages with which the *Discinites* specimens should be considered allied. However, the fructification of *Tingia* (*Tingiostachya*), as described by Kon'no (1929), differs strikingly from *Discinites* in some important morphological features. *Tingiostachya* bore unfused sporophylls in whorls of four, each sporophyll producing a single synangial group of four sporangia on its upper surface; it seems unlikely that two types of cones as morphologically dissimilar as *Tingiostachya* and *Discinites* could belong to one and the same natural genus of plants.

All the present evidence considered, then, *Discinites* still retains the status of a genus of detached fructifications, the identity of whose vegetative parts is not established, even though they themselves may be well known as detached foliar organs under a different generic name. This occurrence of *Discinites* is of interest, however, in that it provides not only a link between the floras of the Pennsylvanian and the Permian, but also an additional link between the floras of Europe and North America. It has also served the writer as one of many illustrations of the poorly understood nature of American Permian floras, the alleviation of which condition constitutes one of the outstanding needs of American paleobotany.

[2] Darrah (1938) described two species of *Tingia* (*T. taeniata* and *T. kempiae*) from Texas; according to his locality data, the source of his material is within 1 or 2 miles of the C. B. Read locality (locality 3959), in rocks of the same stratigraphic horizon.

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BOTANY.—*Trapellaceae, a familial segregate from the Asiatic flora.* HUI-LIN LI, Morris Arboretum, University of Pennsylvania.

The genus *Trapella*, like many other genera of plants of temperate eastern Asia, is apparently of a relic nature. It is treated as an anomalous member in the nearest largest family Pedaliaceae, as a result of the earlier prevalent view against unigeneric families. However, the more favored view among taxonomists and morphologists at present is to recognize phylogenetically isolated genera as representing distinct families irrespective of their sizes. It seems that a phylogenetic system of classification can be more readily elucidated by recognizing more families with clearcut circumscription rather than fewer, larger, more inclusive but also more ambiguous ones. The tendency now is to segregate more and more such isolated genera into independent families of their own. The case of *Trapella* is summarized below.

Trapellaceae, fam. nov.

Pedaliaceae tribe Trapelleae Oliver in Ann. Bot. **2**: 110. 1888; Stapf in Engler and Prantl, Natur. Pflanzenf. IV. **3b**: 260, 265. 1895.

Herba natans, foliis oppositis petiolatis, inferioribus lineari-oblongis denticulatis superioribus deltoideo-rotundatis vel cordiformibus crenato-denticulatis.

Flores axillares solitarii pedunculati. Calyx tubo ovario adnato, limbo libero 5-fido. Corolla perigyna tubuloso-infundibuliforma, limbo patente bilabiato, labio superiore breviter bifido, labio inferiore trifido; tubo basi abrupte angustato, aestivatione imbricata, labio superiore exteriore. Stamina pollinifera 2 epipetala inclusa, antheris bilocularibus, connectivo peltato carnosulo insidentibus; filamentis filiformibus glabris; staminodia antica 2 elongata; stamen posticum nullum. Ovarium inferum apice tantum liberum biloculare, loculo antico rudimentario, loculo postico biovulato; stylo gracile elongato, stigmate bilabiato; ovula 2, anatropa, pendula, superiore sessili, inferiore breviter funiculato deinde abortivo. Fructus angustus elongatus monospermus indehiscens, apice appendicibus 5 coronatus elongatis arrectis apice uncinatim incurvis, 2 brevioribus spinosis subulatis rectis patentibus; pericarpio tenuiter charteceo-lignoso. Semen pendulum, cylindraceum, endospermio tenui, embryonis recti radicula supra, cotyledonibus lineari-oblongis radicula brevioribus.

One genus, *Trapella*, with two species, widely distributed in eastern Asia.

Trapella is one of the most interesting plants discovered in China. It is an aquatic plant with the appearance of *Trapa* but is very different in its characters. At first one species was known for the genus, *T. sinensis* Oliver (1887), first described from central China but later known to occur also in eastern, northern, and northeastern China as well as Japan. Glück (1939) later discovered that the genus is actually composed of two species, one, *T. sinensis* Oliver, in Kyushu of Japan, maritime Siberia, and northeastern as well as northern, eastern, and central China, and another *T. antennifera* (Léveillé) Glück, in Honshu of Japan, northeastern China, and maritime Siberia only.

Trapella, since its discovery, has remained in the Pedaliaceae assigned by the original author. When Oliver first described this plant, he was very much impressed by its uniqueness. His assignment of the genus in the "Pedalineae" is, however, tentative, as he noted that exceptions might surely be taken for this action. He did so not because of the agreement of the genus in all essential characters with the Pedaliaceae, but mainly to avoid the alternative of making this the type of a distinct "order."

Oliver noted that *Trapella* is intermediate in its characters between the Pedaliaceae and Myoporaceae and that it can be considered as an aberrant member, taken to aquatic habits, of the Pedaliaceae, which have all other species terrestrial. The genus is distinct from other genera of the family not only in the aquatic habit but also in the geographical distribution. All other genera of the Pedaliaceae are shore and desert plants in tropical Africa, Madagascar, the Indo-Malayan region, and tropical Australia. The tropical and subtropical American genera formerly included in the Pedaliaceae are now separated as a distinct family Martyniaceae.

Trapella was treated as representing a distinct tribe Trapelleae in the Pedaliaceae by F. W. Oliver (1888–89) and this was followed by Stapf (1895), who recognized the other genera as forming the tribe Pedalieae.

A very thorough study on the morphology of the vegetative as well as reproductive structures of this very anomalous genus was made very shortly after its discovery by F. W. Oliver (1888–89), son of the original author. Young Oliver is of the opinion that *Trapella* is related more closely to Myoporaceae and Pedaliaceae than other families of the "bilabiate monopetalae." He regards the wide discrepancies between Pedaliaceae and *Trapella* as due to the change of habit in the latter, and he refrains from making the genus a new family because he considers the Pedaliaceae, Myoporaceae, and other related families as mostly ill-defined. A very detailed description of the genus is given in his paper, basing on the original description of the genus with modifications and additions resulting from his intensive studies. The diagnosis of the family as given above is adopted from his detailed description. An intensive taxonomical and morphological study of the genus was made also by Glück (1941).

In morphological characters, the chief distinction of *Trapella* from the Pedaliaceae are the inferior ovary and the presence of only two fertile

stamens. Its relationship with the Pedaliaceae is indicated with *Pedalium*, in the bilocular ovary with two pendulous ovules. The appendaged fruit forms a strongly analogous character with the Pedaliaceae. In the form and arrangement of the seed it is near the Myoporaceae but it differs in the fruit and the opposite leaves. *Trapella* thus can be considered as representing the type of a distinct family somewhat linking the Pedaliaceae and Myoporaceae.

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TAXONOMY.—*For and against the doctrine of prescription as applied to taxonomy: A historical retrospect.* AUSTIN H. CLARK, U. S. National Museum.

In these days of renewed interest in taxonomy and in revisions of and emendations to the International Code of Nomenclature it is perhaps of interest to put on record the sentiment expressed by the leading zoologists and paleontologists of nearly 50 years ago.

In the early years of the present century systematic zoology, including paleontology, was in high favor. Previously unknown species were being discovered in large numbers by expeditions to various little-known parts of the world and through the intensive exploration of the deep sea, and material that had been collected earlier was being intensively studied. This work, especially the revisionary studies connected with it, naturally focused attention on taxonomy.

Many names in general use were found to be untenable according to the strict application of the Rule of Priority. In accordance with the rule of priority an International Code of Nomenclature had been drawn up, based chiefly on previous codes concerned mainly with terrestrial vertebrates. This code proved of great value in stabilizing zoological nomenclature, but its strict application in certain cases led to the suppression of many well-established names in general use (as for example *Holothuria*) and also to interminable controversies regarding species inadequately described by early authors of which the type specimens had disappeared. Furthermore, the fossils did not come under the binomial principle elaborated by Linnaeus; they were made exceptions through ignorance of their true nature.

The binomial system was slow in becoming established in purely fossil groups, and there was, and still is, much controversy in regard to the binomial status, or otherwise, of many of the works of the earlier authors.

Dissatisfaction with the inflexibility of the Code and with its arbitrary interpretation and application at that time was becoming marked, and so in 1909 the Hon. Frank Springer of the Territory of New Mexico, the well-known authority on the fossil crinoids, and leader of the New Mexican bar, and I decided to test the prevailing attitude toward it on the part of our colleagues.

The genera *Encrinus*, *Pentacrinus*, *Isocrinus*, and *Millericrinus*, among the best known and most firmly established of all the genera of the Crinoidea, are all either untenable or of doubtful availability according to the strict application of the current code of zoological nomenclature adopted by the International Zoological Congress. In a circular dated Burlington, Iowa, May 1, 1909, Mr. Springer gave a summary of the involved history of the genus *Encrinus* and showed that great confusion would result if the genotype were determined according to the strict application of the rules.

Encrinus liliiformis is the best known of all the stalked crinoids. It has been figured and described under that name in countless works, and specimens are found under that name in all the important cabinets and museums of the world. *Encrinus* Blumenbach, 1779, is generally accepted, with the

genotype *Encrinus liliiformis* Lamarck, 1801. But according to a strict application of the code *Encrinus* should date either from Andreaë, 1763, with the genotype *E. coralloides*, which is supposed to be the terminal stem branches or roots of a species of *Millericrinus*, one of which has been referred to *M. echinatus* by de Loriol; or from Blumenbach, 1779, with the genotype *Isis asteria* Linné (= the Recent West Indian *Cenocrinus asteria*); *liliiformis* was not included in *Encrinus* by Blumenbach (see A. H. Clark, Ann. Mag. Nat. Hist. (8) **3** (15): 308–310. March 1909). Mr. Springer wrote:

> The results of either of these applications of the name *Encrinus*, one or other of which would be rendered necessary by a strict adherence to the International Code, would be to throw the study of the fossil crinoids into intolerable confusion, not so much for the workers in the group, like myself, who can take immediate cognizance of any change, but for the much larger number of students interested in stratigraphy, paleontology, general geology, and allied subjects. The shifting of the names, commonly accepted and heretofore unquestioned, of the commonest genera—genera predominantly characteristic of certain horizons—would impose an intolerable burden upon every one who ever had any occasion to refer to the crinoids in any way. The change, even if it could finally be brought about, would take years to accomplish, and the burden would fall heaviest on those to whom crinoids were only of incidental interest, though of the greatest indirect importance, in the identification of strata, or in the instruction of students. The result would be hopeless confusion, would benefit nobody, and could not fail to bring ridicule upon the taxonomic methods now in vogue.
>
> Moreover, it must be borne in mind that the fossils did not come under the binomial principal as elaborated by Linnaeus; they were made exceptions through ignorance of their true nature. Thus we find that the binomial system was slow in becoming established in purely fossil groups, and there will always be controversy in regard to many of the works of the earlier authors.
>
> The underlying principle of the rule of priority is said, and properly said, to be *fixity*. Yet by insisting upon its absolute and unbending application in all cases, without regard to circumstances, we may destroy the very fixity for which we contend. There is no law more deeply rooted in the foundations of civil government, or more essential to the welfare and stability of society, than that of the fixity of the titles to real estate based on priority. But just as that law in actual administration is subject to exceptions founded upon principles of natural justice and the dictates of public policy, so I think we may find reasonable basis for an exception to the rule of priority in nomenclature which will meet such cases as this.
>
> This would be that such cases, irrespective of the actual state of the record as to their dates, should be protected under an exception to the rule, simply on the ground of long use, on the doctrine of prescription, which is a principle well known in law, recognized in continental Europe as coming down from the civil law of Rome, and now embodied in statutes in all English-speaking countries. It is that the right of property will be upheld by the courts in favor of one who can show a long, continuous, and undisputed possession of it, under a claim of right, however defective, notwithstanding he has no paper title, and even though the records may show the prior title to be in some one else. This rule of law rests upon the idea that it is for the public interest that there be an end of controversy, and that there shall be some reasonable time after which titles may be held safe from attack on any ground. And this end was attained in the beginning, not by denying or abrogating the law governing the conveyance of property by deeds, but by invoking a simple presumption, founded on the known as usual conduct of men with regard to their interests, that where such long and undisputed possession existed there must have been a good title, the evidence of which is lost.
>
> This principle of jurisprudence is now recognized throughout the civilized world as one of the most salutary and beneficial provisions for preventing injustice and insuring that repose of titles which the peace and order of society demand. By virtue of its operation a title by lapse of time merely, if properly proven under all the safeguards which are prescribed in practice to prevent the abuse of it, is as good in the actual possessor as a paper title showing priority by an unbroken chain of recorded deeds. If this be true with regard to matters of such vital importance as the titles to our landed property, why may not the same principle be invoked in favor of repose and stability of names in our scientific literature? It is not a question of "doing justice" to any particular ancient author. The proposition is one of far broader significance, and involves the paramount interest of the scientific public.
>
> In this way, by analogy to the practice which prevails in courts of justice touching the most solemn rights of property, a presumably just conclusion can be reached independent of the rule of priority, and without impairing its force in cases to which no such considerations of public policy apply.
>
> In view of the above, I am in favor of making an exception to the rigid application of the law of priority in regard to the exclusively fossil genus *Encrinus*, accepting it from Schulze, 1760,[1] by

[1] Mr. Springer wrote that Schulze's work "was mainly a compilation from former authors, as Linck, Lluyd, Seba, Capelier, and Ellis, and he uses their names in the same manner as they did, with but small pretense to binomial application.

which means all the above mentioned genera of crinoids [*Encrinus, Pentacrinus, Isocrinus,* and *Millericrinus*] would be retained in the same significance in which they are used today, and have been used for the better part of a century.

Mr. Springer concluded "I am asking you to indicate on the enclosed card whether, in view of the above considerations, you are in favor of making an exception to the International Code in favor of *Encrinus*, or whether, in your judgment, the best course would be to adhere strictly to it in this case, notwithstanding the deplorable confusion which would result."

The enclosed postal card, which was addressed to me, had two alternatives, each followed by a line for a signature. The alternatives were:

(1) I am in favor of accepting *Encrinus* from Schulze, 1760, and of retaining it and the other crinoid genera affected in the same sense as understood today.

(2) I am in favor of a strict adherence to the International Code, regardless of the effect on the present nomenclature.

This circular was sent to 1,000 zoologists and paleontologists.[2]

We received 376 replies to the circular, from Algeria, Brazil, Canada, Ceylon, Denmark, Egypt, Eire, England, Finland, France, Germany, Italy, Japan, Netherlands, New South Wales, New Zealand, Norway, Philippines, Portugal, Queensland, Russia, Scotland, South Australia, Sweden, Tasmania, Trinidad, B.W.I., United States, Victoria, and Western Australia.

Of these replies 297 (nearly 80 per cent) favored retaining *Encrinus*, and 62 (about 20 per cent) favored strict adherence to the Code, a number of them with reluctance.

To show the broad general interest taken in this matter at that time it may be mentioned that among those who replied were Alexander Agassiz, Count Arrigoni Degli Oddi, Lord Avebury, E. G. Conklin, Theodore Gill, Sir Sydney Harmer, Ernst Hartert, John B. Henderson, Jr., Edgard Hérouard, John C. Merriam, Edward S. Morse, Adam Sedgwick, Sir D'Arcy Thompson, A. E. Verrill, Charles D. Walcott, and Alfred Russel Wallace.

Following is an analysis of the replies.

FOR RETAINING ENCRINUS

Of those who returned the cards or wrote letters 243 favored the first alternative, the acceptance of *Encrinus* from Schulze, 1760, without comment. Among these were:

George Abbott, Charles C. Adams, Nicolai Adelung, Alexander Agassiz, M. J. Ahern, A. Alcock, Edward Phelps Allis, Jr., Richard John Anderson, A. W. Anthony, Prof. Dr. Appellöf, Count Arrigoni Delgi Oddi, E. A. N. Archer, Chr. Aurivillius, Lord Avebury [formerly Sir John Lubbock], G. E. H. Barrett-Hamilton, Walter B. Barrows, R. S. Bassler, F. E. L. Beal, Tarleton H. Bean, C. William Beebe, F. Jeffrey Bell, Charles P. Berkey, S. W. Berger, A. Bibbins, W. B. Benham, M. A. Bigelow, H. P. Blackmore, J. E. V. Boas, L. A. Borradaile, Adam Bøving, H. Bolton, Aug. Brinkmann, Hjalmar Brock, Arthur Erwin Brown, J. Büttikofer, W. T. Calman, Oskar Carlgren, J. W. Carr, W. D. Carr, Thomas L. Casey, George H. Chadwick, Robert E. Coker, Leon J. Cole, E. G. Conklin, H. Coutière, William A. Cunningham, Ulric Dahlgren, W. Boyd Dawkins, R. Etheridge, W. L. W. Field, G. H. French, John H. Gerould, O. C. Glaser, E. L. Goldsborough, Seitaro Goto, L. C. Graton, Laurence E. Griffin, R. J. Lechmere Guppy, Robert Gurney, H. J. Hansen, Chas. W. Hargitt, Clemens Hartlaub, Sir Sydney F. Harmer, John B. Henderson, Jr., Junius Henderson, P. P. C. Hoek, S. J. Holmes, A. D. Hopkins, Walter Howchin, I. Ijima, Hartley H. T. Jackson, Robert T. Jackson, Otto Jaekel, O. A. Johansen, Lynds Jones, Chauncey Juday, Hector F. E. Jungersen, W. C. Kendall, John T. Kemp, J. Graham Kerr, H. Kirkpatrick, K. Kishinouye, N. Knipowitsch, K. Kraepelin, B. W. Kunkel, H. H. Lane, Torsten Lagerberg, J. M. R. Levinsen, Edwin Linton, F. A. Lucas, William Lundbeck, Henry H. Lyman, Richard C. McGregor, A. Gibb Maitland, B. Pickman Mann, E. L. Mark, Geo. W. Martin, K. Martin, O. Maas, S. E. Meek, E. A. Minchin, John Mitchell, Henry Montgomery, Roy L. Moodie, Carlos Moreira, Edward S. Morse, Th. Mortensen, Henry F. Nachtrieb, John Treadwell Nichols, A. M. Norman, Hj. Östergren, Paul Pallary, Raymond Pearl, G. Pfeffer, A. L. Quaintance, Wilhelm Ramsey, Herbert W. Rand, Paul M. Rea, C. Tate Regan, Jacob Reighard, Robert

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He did not propose *Encrinus* to represent a genus, but only mentioned, by way of recital, the fact that certain petrifactions resembling a lily have been called the lily-stone, *Encrinus* ('Man findet eine gewisse Versteinerung, die, in Ansehung ihrer Gestalt, einige Gleichheit mit einer Lilie zu haben scheinet, daher man dieselbe enfänglich fur die Versteinerung dieser Blume gehalten, und sie den Lilienstein, ENCRINUM, genennen hat.'). On plate IV is a figure of a complete crown of the fossil to which he refers, and in the long description which follows he mentions it four times by the name 'Lilienstein,' but never again as '*Encrinus*.' The figured specimen is *E. liliiformis* Lamarck."

[2] See Austin H. Clark, The strict application of the law of priority to generic names, Science, n.s., **31** (787): 145–146. January 28, 1910.

Ridgway, Alice Robertson, Rudolf Ruedemann, G. O. Sars, R. S. Scharff, W. L. Sclater, E. A. Schwarz, H. H. Scott, Adam Sedgwick, H. W. Shimer, C. Ph. Sluiter, Frank Smith, Grant Smith, John B. Smith, Sanderson Smith, T. Southwell, J. W. Spengel, E. C. Stirling, F. B. Sumner, W. M. Tattersall, Hjalmar Théel, Sir D'Arcy W. Thompson, Charles D. Walcott, P. R. Uhler, E. O. Ulrich, A. E. Verrill, Gen. A. W. Vogdes, U.S.A., B. E. Walker, Henry B. Ward, Stuart Weller, W. M. Wheeler, R. P. Whitfield, C. O. Whitman, W. H. Wickes, S. R. Williams, S. W. Williston, Chas. B. Wilson, Herluf Winge, Lorande Loss Woodruff, H. Woods, Horace B. Woodward, J. B. Woodworth, and Dean C. Worcester.

In addition to these, 54 zoologists and paleontologists were in favor of retaining *Encrinus* as suggested, but added comments. These may be classified as follows.

1. Questions such as this should be presented to the International Commission to be adjudicated by the Commission itself or by a committee or committees appointed by the Commission. Among those taking this view were:

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and long accepted familiar names in any branch of natural history, resulting as it does in constant confusion and discouragement, especially to the uninitiated."

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Finally, one card from Dorchester, England, read "I am in favor of accepting *Encrinus* Schulze, 1760 . . . but I should prefer a postal order for five shillings to be sent to Timothy Scroggins, Warwick Gaol, and to be given me when I have finished my time."

Since this poll was taken the principle of prescription has been adopted by the International Commission on Nomenclature, and a list of *nomina conservanda* has been established.

All the cards and the letters referred to above have been mounted in a scrapbook, which is filed in the Library of the Smithsonian Institution.

ZOOLOGY.—*On* Polyclinum indicum, *a new ascidian from the Madras coast of India*. V. O. SEBASTIAN,[1] University Zoology Research Laboratory, Madras, India. (Communicated by Fenner A. Chace, Jr.)

While engaged in a study of the ascidian fauna of Madras coast, I was able to identify a new species of *Polyclinum*, the structure of the zooid, larva, and postlarval stages of which forms the substance of the present paper. Herdman (1891) has described *P. constellatum* and *P. isiacum* from the Indian Ocean, and a doubtful species (1906), *P. nigrum*, from the gulf of Manaar. Sebastian (1942) has published an account of the anatomy and larval organization of *Polyclinum* sp. obtained from a dredge collection off the coast of Madras and later (1952) described as *P. madrasensis* Sebastian. The present form, **Polyclinum indicum**, n. sp., is the commonest synascidian found along the rocky shores of the Madras coast. The colonies are found attached to the under surface of stones and boulders, at the level of the tides, on the Royapuram coast, north of Madras harbor. The places where they grow are always subjected to the action of violent waves.

External appearance.—The colonies vary in shape, younger ones being oval or pear-shaped with narrow bases of attachment and round upper exposed surfaces (Figs. 1, 2). The full-grown colony has an umbrella-shaped upper exposed surface, the base of attachment being broader, but narrower than the diameter of the upper region (Fig. 3). The mature colony has a diameter of 2 to 2½ inches, and a height of 1½ to 2 inches. The common cloacal openings are found scattered on the exposed surface, raised on conical projections of the outer test. The surface is encrusted with a thin layer of sand. The color is light brown or pale red in the majority of cases. Rarely the color is dull green, but except for this the anatomical features are the same. Several colonies, large and small, could be seen closely applied to one another, the different-colored colonies occurring in the same group.

The zooids are arranged in systems of about 20 to 40, three or more such systems found around one common cloacal opening forming a pattern (Fig. 4). The branchial openings have a whitish color on their margins. A cross section of the colony (Fig. 5) shows the disposition of the zooids inside the test. They are arranged toward the outer periphery, their long ampullae running throughout the length of the test in various directions. The test is transparent, having a tinge of either red or green according to the color of the colony.

Structure of zooids.—The length of the zooid (Fig. 6) from the branchial siphon to the tip of the postabdomen is about 2.3 to 3.2 mm. The abdomen is about one-half and the postabdomen three-fourths the size of the thoracic region. The shape and proportion of the various regions of the zooids may vary slightly according to the manner in which each zooid is pressed into the group forming a system. The *branchial siphon* is 6-lobed. The *atrial siphon* is a wide space exposing a part of the branchial sac, which is a characteristic feature. At the anterior edge of the atrial siphon there is an *atrial languet*, which is leaflike, but

[1] I wish to express my thanks to Dr. C. P. Gnanamuthu, director of the University Zoology Research Laboratory, for his helpful suggestions, and to the authorities of the Madras University for varied assistance rendered.

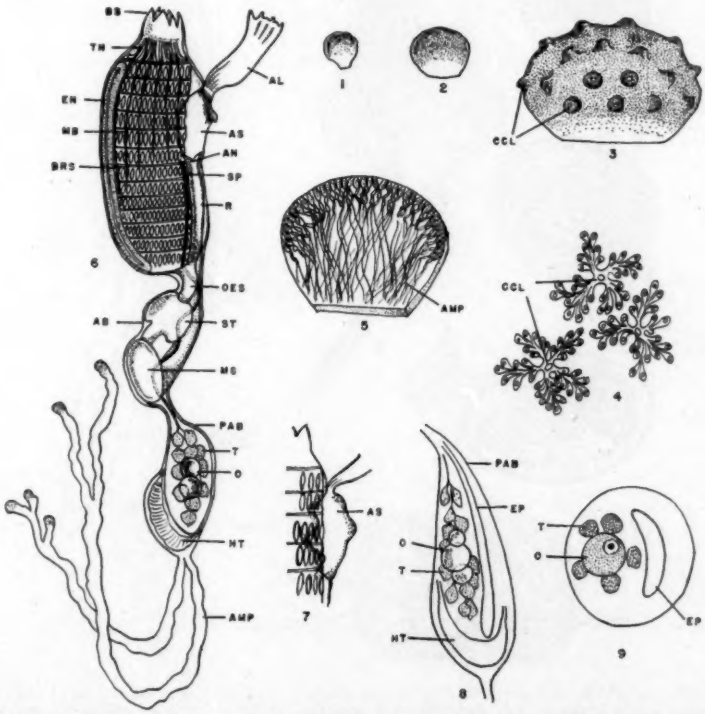
the distal extremity is blunt with a few protuberances. The size and shape of the languets vary according to the distance of the zooid from the common cloacal opening, those farthest being longer and more pointed, those nearest, shorter and blunt. The languet appears to be the enlarged anterior lobe of the opening, the other lobes having failed to develop to their full size. Rarely vestiges of the other lobes are also seen (Fig. 7). The *muscle bands* are six pairs on the mantle wall, extending only up to about the middle of the thoracic region.

The *thorax* is cylindrical. There are about 13 to 15 rows of stigmata, with 14 to 16 elliptical stigmata in each row. In smaller zooids the number may vary from 12 to 14. Each transverse vessel bears a series of minute papillae on its inner free margin. The *dorsal lamina* is in the shape of languets. The *tentacles* are simple varying from 12 to 16, their free ends being slightly swollen.

The *abdomen* when viewed as a whole is kidney-shaped. There is a funnel-shaped *esophagus*, followed by a *midgut* and *rectum*, the whole system bent and twisted into a U with unequal limbs. The rectum opens at the posterior edge of the atrial siphon, the anal opening situated between two lobes.

The *postabdomen* is connected to the abdomen by a short narrow stalk which gradually widens to hold the gonads and heart. The *testis* consists of follicles in the shape of bunches of grapes all connected together by narrow ducts. The *ovary* is found to occupy the middle portion among the mass of sperm bunches, and shows eggs of various sizes. The sperm duct and oviduct run together and open near the level of the rectal opening. Posterior to the gonads and slanting in disposition is the *pericardium* enclosing the *heart*. A thin-walled *epicardium* runs along the side of the gonads (Figs. 8, 9): its posterior extremity comes to the middle bend of the heart.

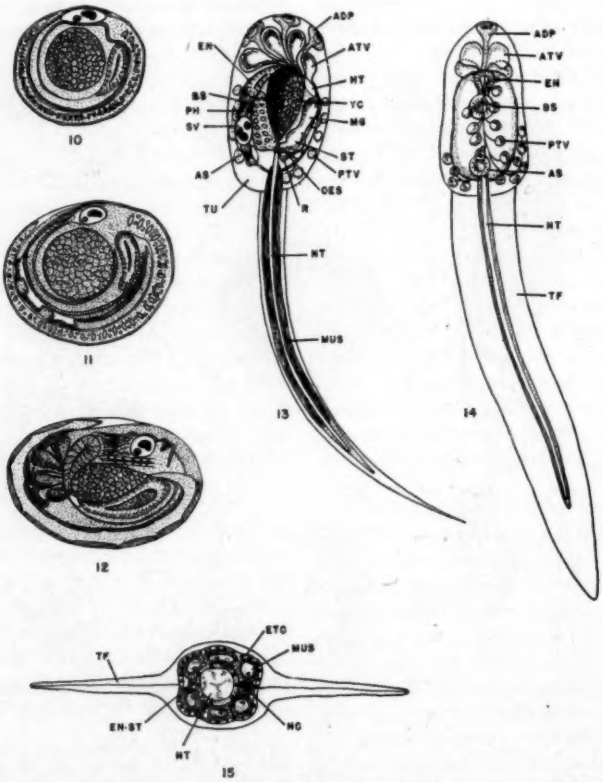
Sexual reproduction.—Eggs undergo development inside the atrial chamber, and tadpole lar-



FIGS. 1–9.—*Polyclinum indicum*, n.sp.: 1, 2, Young colonies; 3, mature colony; 4, surface view showing the grouping of zooid systems; 5, a thin solid section of a colony; 6, mature zooid; 7, atrial siphon with vestiges of lobes; 8, postabdomen; 9, cross section of postabdomen.

vae when mature are liberated in swarms. Breeding occurs throughout the year. Colonies collected and kept in troughs of sea water liberate larvae at any time of the day. The egg measures 0.25 mm and has a yellowish tinge due to the presence of yolk. A few stages of developing embryos are shown in Figs. 10–12.

Tadpole larva.—The tadpole (Fig. 13) measures 1.66 mm from the adhesive papillae to the tip of the tail fin, the trunk measuring 0.32 mm and the tail 1.34 mm. The *tunic* covers the whole body and tail of the larva. In the region of the tail, the tunic is expanded into the tail fin, which is horizontal in position owing to the rotation of the tail (Fig. 14). *Test vesicles* ("tunic vesicles," Scott '46) are of two sets, one directed anteriorly and the other posteriorly. The anterior ones are club-shaped and arranged in a ring of eight in two rows of four each, arising from the anterior ectodermal margin of the body of the larva, and spreading out with a slant toward the dorsal side. The middle two pairs are longer, measuring 63.2μ, and the lateral ones smaller, measuring 47.4μ. The posterior test vesicles are in the nature of bunches of grapes, one set dorsal and one ventral in position, with long narrow tubular stalks from which arise pinnately arranged branches ending in round hollow vesicles containing mesenchyme cells. They are of ectodermal origin, the stalks arising from the anterior margin of the trunk, from their respective dorsal and ventral sides, at the level of the origin of the anterior test vesicles. *Adhesive papillae* are three in number and arise from the anterior ectodermal margin of the trunk between the ampullae. Each one of them has a long narrow tubular stalk, the distal extremity of which swells into a goblet containing a central mass of columnar secretory cells, all converging to a point in the central opening (Fig. 19). Grave (1921) has stated that the

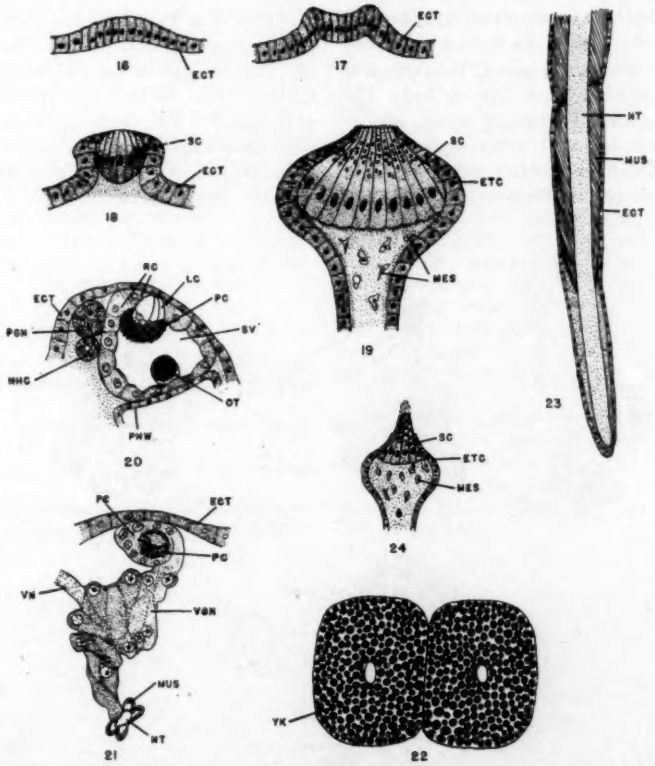


FIGS. 10–15.—*Polyclinum indicum*, n.sp.: 10–12, Developing embryos; 13, tadpole larva, side view; 14, tadpole larva, dorsal view; 15, Transverse section of tail of larva.

secretory cells of the adhesive papillae in *Amaroucium constellatum* are modified mesenchyme cells. Sebastian (1942) has found them to be of ectodermal origin in *Polyclinum* sp. (*P. madrasensis*), formed by the intucking and elongation of the ectodermal cells of the papillae, similar to the condition found in the cement glands of certain fishes and amphibian larvae (Asheton, 1896; Jones, 1937; Bhaduri, 1935). Scott (1946), studying the larval organization of *A. constellatum*, has also found that these cells are of ectodermal origin. The same kind of ectodermal origin of the secretory cells of the adhesive papillae in *P. indicum* is illustrated in Figs. 16–19. The *mantle* or ectodermal covering of the body and tail is made up of one layer of cells with distinct nuclei, containing a large number of yolk granules. The layer covering the trunk has cubical cells which gradually become thinner and flattened in the tail region. In the region of the branchial and atrial siphons these cells are columnar.

The *nervous system* consists of the *sensory vesicle* with the contained *ocellus* and *otolith*, *visceral ganglion* with the *visceral nerve*, and *nerve cord*, of the larval action system, and the *permanent ganglion* and *hypophysial duct* of the adult system (Figs. 20, 21). The sensory vesicle is situated between the branchial and atrial siphons to the right side. The ocellus consists of three lens cells, pigmented optic cup and associated retinal cells. The otolith is single-celled with a perfectly spherical pigmented mass at its distal end.

The *digestive tract* (Fig. 13) is a bent tube including the *pharynx*, *esophagus*, *intestine*, and a short *rectum*, which ends blindly near the level of the esophagus. There is a middle mass of yolky cells, conical in shape, the narrow portion being connected with the endodermal layer by a short

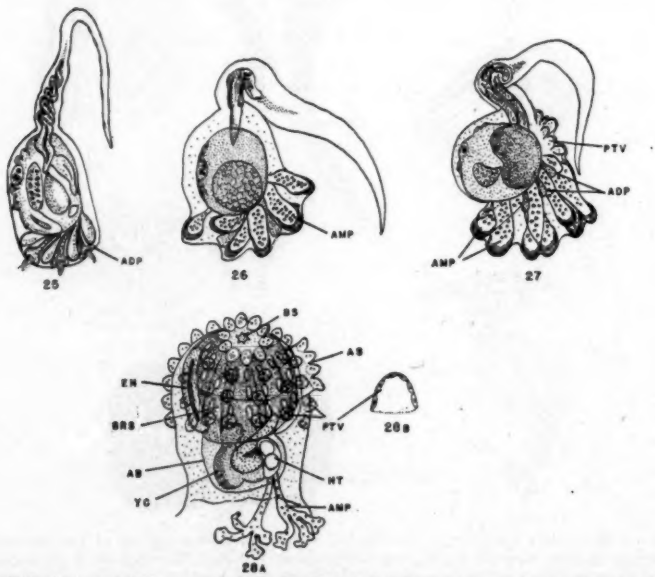


FIGS. 16–24.—*Polyclinum indicum*, n.sp.: 16–18, Stages in the formation of the secretory cells of adhesive papillae; 19, goblet magnified; 20, sagittal section through the region of the sensory vesicle; 21, section passing through the visceral ganglion; 22, Transverse section of yolky cell mass; 23, magnified view of the posterior extremity of tail of larva; 24, secretory cells of the goblet being shot out.

stalk. In transverse sections it is found to be formed of two squarish portions (Fig. 22), each having a narrow central cavity. The *endostyle* is placed on the anterior margin of the pharynx, one edge of it touching the anterior edge of the yolky mass. The pharynx has two rows of stigmata on each side, each row having about eight stigmata. On the ventral side of the yolky mass toward the anterior side is situated the *pericardium* and *heart*.

The *notochord* forms the central core of the tail (Fig. 15); it has 40 cells placed one behind another in a row. In the full-grown larva the boundaries of notochordal cells are not clearly seen. Owing to the twist of the tail at an angle of 90° to the left the nerve cord is found on the left and the *endodermal strand* on the right side of the notochord. The muscle bands situated dor sally and ventrally do not extend up to the posterior extremity of the notochord (Fig. 23). Each band is formed of three rows of muscle cells, each row of seven cells, placed one behind the other. There are only two rows of cells on the portion of the notochord which projects into the body. The muscle cell has a darkly staining cortex, and an inner vacuolated core with cytoplasmic strands and nucleus. The disposition of the striations is oblique, as described by Grave (1921), Conklin (1931), Scott (1946), and Berrill (1947). The ectoderm of the tail forms the outer covering of the muscles.

Metamorphosis of the larva.—The free-swimming period lasts 5 to 8 hours. At the time of fixation the secretory cells of the adhesive papillae shoot out of the goblet, exuding their secretory product (Figs. 24, 25). The tail gets resorbed, and the anterior ampullae elongate and spread out in an irregular way (Figs. 25–27), attaining their maximum length of 0.24 mm in 2 hours after the tadpole has become fixed. The heart begins to beat after 3 hours, the siphons contract after the fifth hour, and the intestine functions 10 hours after fixation. Complete resorption of the tail does not take place in most of the cases during the changes described above. At least a quarter of the original length, and in some cases even half, of the tail remains unchanged for about 12 hours, and in certain cases for more than 24 hours. The posterior ampullae do not disappear immediately after metamorphosis. They enlarge in size and remain all over the surface within the tunic as pyramidal projections (Fig. 28a, b); their walls are made up of a very thin unicellular layer. The ducts that connect them are not found during this time. These vesicles are clearly visible for a week or more, later



FIGS. 25–28.—*Polyclinum indicum*, n. sp.: 25–27, Stages in the metamorphosis of tadpole larva; 28a, a functional oozooid, 48 hours old; 28b, magnified view of a single posterior test vesicle.

disappearing by bursting and releasing the mesenchyme cells lodged inside them. Under laboratory conditions it has not been possible to keep alive the metamorphosed stages for more than 10 to 13 days; the size attained in 4 to 5 days remains without any change for the rest of the days. The abdomen descends partially (Fig. 28a), but the descent of the postabdomen has not been observed.

Validity of the Species.—Zooids as well as larvae of *Policlinum* are alike, differentiating characters being minor. Berrill (1950) remarks that "in zooid structure, though less so in form of colony, species of *Policlinum* are very much alike, and even the tadpoles and larvae appear to differ only in size." Van Name (1945) says that "the true *Polyclinum* are all very closely related to each other, their zooids apparently having nearly the same structure, so that we must depend chiefly on the gross characters of the colonies for distinguishing them. A supposed difference in the number of branchial tentacles (whether in multiples of 4 or 6) appears to be of questionable value as a specific character, multiples of 6 being probably normal, though subject to irregularities." The present species closely resembles *P. planum* in shape and number and rows of stigmata, but it differs in the shape of the atrial siphon, the atrial languet and the slanting disposition of the heart. On account of these differences the present form is given the status of a new species, *P. indicum*.

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KEY TO LETTERING ON FIGURES

AB, abdomen; ADP, adhesive papilla; AL, atrial languet; AMP, ampulla; AN, anal opening; AS, atrial siphon; ATV, anterior test vesicle; BS, branchial siphon; BRS, branchial sac; CCL, common cloacal opening; ECT, ectoderm; EN, endostyle; EN.ST, endodermal strand; EP, epicardium; HT, heart; LC, lens cell; MB, muscle band; MES, mesenchyme cells; MG, midgut; MUS, tail muscle; NC, nerve cord; NHC, neurohypophysial canal; NT, notochord; O, ovary; OES, oesophagus; OT, otolith; PAB, postabdomen; PC, pigmented optic cup; PGN, permanent ganglion; PH, pharynx; PHW, pharyngeal wall; PTV, posterior test vesicle; R, rectum; RC, retinal cell; SC, secretory cells; SP, sperm duct; ST stomach; SV, sensory vesicle; T, testis; TF, tail fin; TN, tentacle; TU, tunic; VGN, visceral ganglion; VN, visceral nerve; YC, yolky cells connected with the growth of the postabdomen; YK, yolk granules.

HELMINTHOLOGY.—Psilocollaris indicus, *n.gen., n.sp.* (*Psilostomidae Odhner, 1911: Trematoda*) *from an Indian stork*, Dissoura e. episcopus. KUNWAR SURESH SINGH, Department of Zoology, Lucknow University. (Communicated by Robert Rausch.)

Seven specimens of an undescribed trematode were recovered from the intestine of a stork, *Dissoura e. episcopus* (Boddaert), shot near Lucknow, India, in August 1950. The trematodes were pink in color when alive and were capable of active movement.

Seven genera have been described in the family Psilostomidae: *Psilostomum* Looss, 1899; *Psilochasmus* Lühe, 1909; *Apopharynx* Lühe, 1909; *Sphaeridiotrema* Odhner, 1913; *Psilotrema* Odhner, 1913; *Lyperorchis* Travassos, 1921; *Psilorchis* Thapar and Lal, 1935. The present form differs from all these genera in the possession of a definite collar at the anterior end of the body. It is most closely related to the genera *Lyperorchis* and *Psilorchis*.

For *Lyperorchis*, described from the cloaca of *Aramus scolopaceus*, a slightly developed collar was described by Travassos: "Ventosa oral ladeada por duas saliencias papilliformis." In the present form, however, the collar is well developed, and clearly of the Echinostome type. Indeed if spines were present, these forms would be regarded as typical Echinostomes.

Further, the testes in *Lyperorchis* are sinuous and much elongated whereas in the present form they are typical of the family (i.e., bean-shaped). The oral sucker and the pharynx in the present form are poorly developed as compared to those of *Lyperorchis* and other genera. The arms of the Y-shaped excretory bladder are very much elongated and are longer than the stem, extending to the anterior region of the anterior testis. In the present forms the excretory bladder is Y-shaped but the arms are comparatively very small. In *Psilorchis* the collar is entirely lacking, the oral sucker and the pharynx are comparatively well developed and large in size, and the stem of the excretory bladder is very small and the arms comparatively very long.

Accordingly a new genus is created for these forms, with the following generic diagnosis:

Psilocollaris, n. gen.

Psilostomidae: Body much elongated; oral sucker and pharynx weakly developed, prepharynx small and oesophagus very long, intestinal ceca extend to posterior end of body; slightly developed unarmed collar present at the anterior end; ventral sucker well developed and present in the anterior bodyhalf; testes bean-shaped or oval, and situated one behind the other in the posterior region; cirrus pouch small and partly covered by ventral sucker; genital pore just posterior to intestinal bifurcation; small, rounded ovary in posterior half of body; vitellaria consist of many follicles laterally distributed from ovary into posterior end, though a clear midarea is usually present but the vitellaria may be confluent in regions; uterus with ascending limb only containing many eggs. Parasites of birds.

Type species.—*Psilocollaris indicus*, n. sp.

Psilocollaris indicus, n. sp.

Figs. 1–3

Diagnosis.—Body measures 5.3–16.4 mm in length and 0.384–0.69 mm in maximum breadth. Anterior end is provided with slightly developed collar, not much unlike the collar of an Echinostome, but spines are absent. When viewed from the side the collar appears as a flaplike process (Fig. 2). Collar measures 0.26–0.3 mm across and is not muscular. Oral sucker and the pharynx are comparatively very small and poorly developed. The oral sucker measures 0.506 x 0.024 mm and the mouth opening is very small, sub-terminal, and leads into a small prepharynx. The pharynx, which is larger than the oral sucker, measures 0.069–0.1 x 0.04–0.046 mm. The oesophagus is very long, measuring 0.88–2.0 mm in length. It divides into two intestinal ceca which run laterally to the posterior end of the body, but their extreme terminations could not be observed because of the presence of large number of vitelline follicles. Ventral sucker is comparatively very large and muscular and is situated posterior to the intestinal bifurcation in the anterior fourth of body. The sucker is transversely elongated, and measures 0.27–0.4 x 0.26–0.4 mm. The body is without spines.

The excretory bladder is Y-shaped and the arms are rather wide (Fig. 3). The stem of the bladder extends medially to the posterior end of the posterior testis and the arms are short and do not extend beyond the base of the posterior testis. The excretory pore is situated at the posterior end and is terminal.

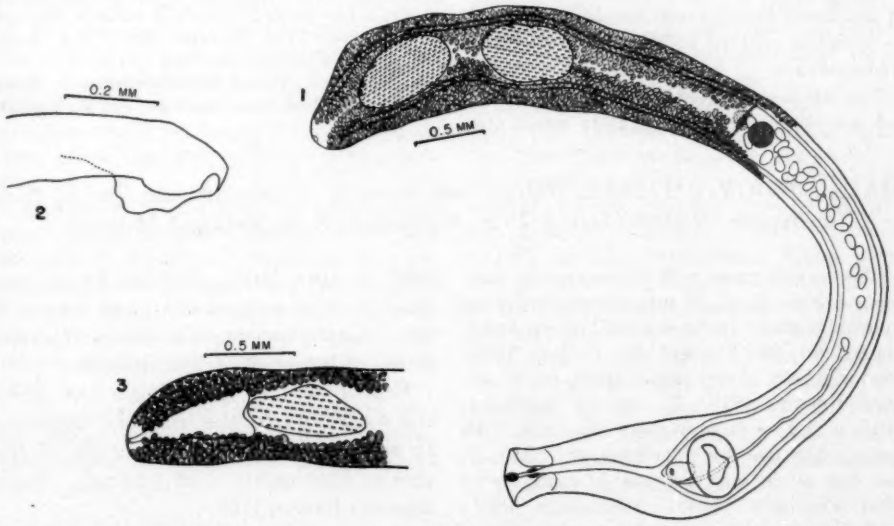
The two testes are present in posterior fourth region of body, one behind the other. The anterior testis, usually slightly smaller than posterior testis, measures 0.43–0.72 x 0.19–0.34 mm. The posterior testis situated about 0.2 mm. posterior to anterior testis, is 0.43–0.83 x 0.21–0.32 mm. Both testes are beanshaped. The cirrus pouch is comparatively small and lies in between the ventral sucker and the intestinal bifurcation. It is somewhat oval and measures 0.16–0.26 x 0.069–0.14 mm. External vesicula seminalis is absent, but a large internal vesicula seminalis is present. Numerous prostate gland cells surround the ejaculatory duct. The genital pore is just posterior to the intestinal bifurcation. Ovary is small and rounded and situated in posterior half of body, anterior to the anterior testis. It measures 0.12–0.184 x 0.099–0.16 mm. Mehlis's gland is slightly smaller than ovary and is present just posterior to it. It is almost rounded and measures 0.13–0.18 x 0.18–0.19 mm. The vitellaria consist of numerous elliptical follicles distributed mainly laterally from level of the ovary to the posterior end of the body. In most specimens, the vitellaria leave a clear space in the middle, but sometimes they are confluent anterior to the anterior testis. Two transverse vitelline ducts meet in the region of Mehlis's gland and form a small vitelline reservoir. Uterus consists of an ascending limb only and after several folds immediately anterior to the ovary it proceeds more or less as a straight tube, opening at the genital pore posterior to the intestinal bifurcation. The eggs are numerous and measure 0.092–0.104 x 0.058 mm.

Host.—*Dissoura e. episcopus* (Boddaert).

Locality.—Lucknow, India.

Habitat.—Intestine.

Remarks.—The genus *Psilorchis* contains three species, all described from India: *P. indicus* Thapar and Lal, 1935; *P. ajgainis* Lal, 1938, and *P. thapari* Baugh, 1949. In *P. indicus* the cirrus pouch is present in front of the ventral sucker but in *P. ajgainis* the cirrus pouch is described as adhering to the ventral sucker and this character has been used to distinguish the two species (Lal, 1938; Lal, 1939). Consequently, the diagnosis of the genus *Psilorchis* should be emended and should read "Vesicula seminalis and cirrus pouch retort-shaped, partially or totally in front of the ventral sucker..." Further, the genital pore in *P. ajgainis* is de-



FIGS. 1-3.—*Psilocollaris indicus*, n.g., n. sp.: 1, Entire worm; 2, collar, lateral view; 3, posterior end, showing excretory bladder.

scribed as "in front of the oral sucker, between it and the intestinal bifurcation." (Lal, 1938, p. 260) An obviously typographical error occurs here.

The excretory system in the family Psilostomidae has been described as "comprising a subcutaneous net-work of vessels and two main lateral canals which unite in front of the ventral sucker to form a long median stem" (Dawes, 1946, p. 99). Unfortunately the details of the excretory system of many of the genera are not known, but in genera like *Psilostomum*, *Lyperorchis*, *Psilorchis*, *Apopharynx* and the present form, the excretory bladder is Y-shaped, the comparative length of the stem and the main branches varying from genus to genus, but in all cases the median stem extends to the base of the posterior testis only. It certainly does not extend anterior to the ventral sucker, as stated by Dawes (1946). Indeed, in the two species of *Psilorchis*, the Y-shaped excretory system is very small. Beaver (1939), who investigated the life history of *Psilostomum ondatrae* Price, 1931, found that the excretory bladder in the cercaria is not elongated and is confined to the posterior end, posterior to the genital anlagen and the ventral sucker. It retains the same comparative position in the adult, though the median stem becomes elongated and the excretory system looks typically Y-shaped. Hence, in the opinion of the author the excretory system in the family Psilostomidae should be described as Y-shaped, without limiting the length of the median stem.

The families Psilostomidae and Echinostomidae are closely related and there seems little difference between the two except for the presence of a collar with spines in the family Echinostomidae. The resemblance is not confined to the adult characters only, since Beaver (1939) found that the miracidia, redia and cercaria of Psilostomes closely resemble those of Echinostomes and the pattern of the life history is the same. In view of such evidence, the presence of a genus with a collar, but without spines, is especially interesting as it joins the two families and may be considered an intermediate form in the evolution of the families Psilostomidae and Echinostomidae.

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MALACOLOGY.—Hydrobia totteni, *new name for* Turbo minuta *Totten, 1834 (Gastropoda: Hydrobiidae)*. J. P. E. MORRISON, U. S. National Museum.

The species name still in use for the commonest New England salt-marsh-inhabiting hydrobiid snail (*Turbo minuta* Totten, Amer. Journ. Sci. **26** (2): 369, fig. 6. July 1834) was originally thrice preoccupied, by *T. minuta* Brown, 1818; *T. minuta* Michaud, 1828; and *T. minuta* Woodward, 1833. This species has been so "well-known" that no one has given any alternative name, even after Sherborn (Index Animalium 1801–1850, p. 4101. 1928) listed the homonyms. Since there is no available name known to me, I hereby rename the species *Hydrobia totteni* in honor of its first describer.

Examination of the animals has shown this species to be a true *Hydrobia*, congeneric *in sensu stricto* with the genotype of *Hydrobia* Hartmann, 1821, namely *Turbo stagnalis* Baster, 1765.

MALACOLOGY.—*Trends and problems in pelecypod classification (the supergeneric categories)*. DAVID NICOL, U. S. National Museum.

Little has been written to guide workers in the various animal phyla in problems of classification in the supergeneric categories. Simpson (1945, pp. 20–24) and Mayr, Linsley, and Usinger (1953, pp. 46–59) have contributed valuable suggestions; but general principles of standardization that could be applied to the higher categories of all phyla are still lacking. The reason is that many of the classification problems of the entomologist or mammalogist, for example, are entirely different from those of the malacologist. From the standpoint of size alone, if not on a morphologic basis, a pelecypod family or other supergeneric category may not be comparable with a family of insects or mammals; this in itself would tend to create different problems in classification in the Insecta, the Pelecypoda, and the Mammalia. Other differences in higher categories of different classes of animals arise from the percentage of described species and the phylogenetic knowledge in the various groups. Hence, standardization at the level of the phylum would be virtually impossible; in fact, about all that can be hoped for in a large phylum is reasonable standardization within a class.

For the purposes of brevity and continuity in this paper, I have decided to treat the Pelecypoda as a class. This has been the most common treatment in the past, although I realize that at least some of our problems might be solved if the Pelecypoda were given the rank of, let us say, a subphylum.

It appears to me that the phylogenetic relationships of the Pelecypoda are not adequately or correctly shown by the present classifications; but, with the excellent fossil record of the pelecypods, these relationships *could* be shown and thus the usefulness of the classification could be improved.

The ideas and problems presented here are mainly those of a malacologist; however, many valuable suggestions and criticisms were given by Dr. R. E. Blackwelder, entomologist at the U. S. National Museum, and for these I am very grateful.

The purpose of this paper is to examine some recent examples of classification of pelecypods used by paleontologists and neontologists, to discuss present trends, and to offer possible solutions to some of the problems. A list of some important works on pelecypod classification is included.

THE SUBCLASS, SUPERORDER, ORDER, SUBORDER

The first example of classification is taken from the paleontology textbook *Invertebrate fossils* by Moore, Lalicker, and Fischer (1952). Moore, who wrote the chapter on the pelecypods, used a modified version of Dall's classification based on the hinge teeth. He divides the pelecypods (pp. 409–412) into two subclasses—Prionodesmacea and Teleodesmacea. In the first group Moore includes five orders and twelve suborders; in the second, in which he combines Dall's orders Anomalodesmacea and Teleodesmacea, he includes three orders and twelve suborders. According to Moore, the Paleoconcha are an order of the subclass Prionodesmacea; Dall, however, did not include them in any of his three orders in 1895 (p. 513) but set them aside as *incertae sedis*, although he later arbitrarily placed them in the Prionodesmacea.

Moore discusses the structure of the pelecypod ctenidia at considerable length but gives the ctenidia little importance in his classification—i.e., in the Prionodesmacea, Moore includes pelecypods with protobranch, filibranch, and eulamellibranch ctenidia. Furthermore, Moore places the anomiids and the spondylids together in the order Isodonta and places the nuculids and arcids together in the order Taxodonta; but on the basis of phylogeny and morphology it is difficult to see these relationships. In the order Dysodonta, Moore includes the mytilids, pectinids, pinnids, ostreids, limids, and dreissensiids—truly a heterogeneous assemblage.

The classification used by Shrock and Twenhofel in their book (1953, pp. 386–393) is that of Thiele, 1934, who divided the Pelecypoda into three orders, Taxodonta, Anisomyaria, and Eulamellibranchia, primarily on the basis of ctenidia, hinge teeth, and adductor muscles. In the order Taxodonta are included the nuculids and the arcids. However, in a footnote (p. 389) Shrock and Twenhofel make the following statement:

> The Arcacea are now regarded by some investigators (MacNeil, 1937; Nicol, 1950) as more closely related to certain groups of the Anisomyaria because the hinge structure is of a later type and may possibly be the result of convergence. It may well be, therefore, that this superfamily should be transferred to the order Anisomyaria or used as the basis for a new order.

Shrock and Twenhofel imply that the lack of close relationship between the arcids and the nuculids is a new idea, but if the authors had examined the writings of Pelseneer and Douvillé they would have found that the idea was presented much earlier than 1937. Furthermore, if my paper of 1950 had been carefully read (p. 89), the following statement would have been noted:

> Pelseneer, Douvillé, and others have pointed out the fact that the prionodonts are not closely related to the true taxodonts such as *Nucula*, *Nuculana*, and *Yoldia*.

This is but one example of the lack of knowledge of the basic works on pelecypod systematics.

A recent and much more comprehensive work is the *Traité de paléontologie* edited by Jean Piveteau, 1952. The major portion of the chapter on Pelecypoda was written by Colette Dechaseaux. The main divisions Dechaseaux uses are based on hinge characteristics, and she divides the pelecypods into four orders—Taxodonta (with three suborders), Dysodonta, Preheterodonta, and Heterodonta. Only the taxodonts are divided into suborders, one of which is the Paleoconcha. By far the largest order is the Heterodonta, which is comprised of more than half of the pelecypod families.

Dechaseaux's classification bears little resemblance to her schematic table on the evolution of the pelecypods (page 229). This is just one example of workers who, although cognizant of phylogenetic evidence, do not base their classification on phylogeny but, instead, follow the line of least resistance by using the outmoded classification of a predecessor. As long as this attitude occurs, little progress can be made in the classification of the pelecypods.

Another work worth analyzing is that of T. Habe (1951–1953), who uses Dall's classification with few modifications. Habe divides the Pelecypoda into three subclasses—Prionodesmacea, Teleodesmacea, and Anomalodesmacea. The first subclass is divided into four orders, and the Teleodesmacea is divided into two orders. Habe does not group the Anomalodesmacea above the level of superfamily. The categories superorder and suborder he does not use at all in his classification of the pelecypods.

Habe places the nuculids and arcids in the order Taxodonta, although, as has been pointed out before, they bear only a superficial resemblance to each other. Furthermore, although most of the Cenozoic arcids and nuculids do have similar hinges, the hinge teeth of the Mesozoic and Paleozoic arcids and their allies are generally quite unlike those of the nuculids. Thus, from the practical standpoint of classification, disregarding phylogeny, this grouping is not workable.

Little attempt is made by Habe to show relationships in the order Heterodonta, to which he assigns 14 superfamilies and 34 families.

The comprehensive treatment of the classification of the Pelecypoda by Cotton and Godfrey (*The molluscs of South Australia*, 1938) is also noteworthy. These authors subdivide the class into the three orders proposed by Dall. The order Prionodesmacea is subdivided into five suborders—Palaeoconcha, Taxodonta, Schizodonta, Isodonta, and Dysodonta—which are in turn divided into superfamilies and families. The order Anomalodesmacea is not grouped above the level of superfamily; however, the authors use the category "section" between the superfamily and family. Cotton and Godfrey subdivide the order Teleodesmacea into five suborders—Pantodonta, Diogenodonta, Cyclodonta, Teleodonta,

and Asthenodonta—and these suborders are further divided into numerous superfamilies.

Once again we find the unlike nuculids and arcids grouped together in the suborder Taxodonta. Cotton and Godfrey place the pteriids, ostreids, unionids, and trigoniids in the suborder Schizodonta; certainly the ostreids do not belong with such primitive nacreous groups. The grouping of the venerids, tellinids, solenids, and mactrids in the suborder Teleodonta seems arbitrary and appears to be based on little or no phylogenetic and morphologic evidence.

All the foregoing examples show certain common characteristics which are important as well as interesting. They are as follows:

1. In none of the treatments reviewed of the classification of the class Pelecypoda are all the common categories used, i.e., subclass, superorder, order, suborder, superfamily, family, and subfamily.

2. None of the classifications is basically new. With one exception, each author follows one authority almost exclusively with perhaps minor modifications; the one exception uses a combination of basic characters and classifications.

The fundamental concepts for classifying the Pelecypoda were mainly promulgated between the years 1889 and 1912. It was during this period that the morphologists, embryologists, and evolutionists were most intensively working on natural, or phylogenetic, classifications of the Pelecypoda. Since that time only a few details of classification have been added. Even thorough review and synthesis of the classifications have received little interest lately. This basic pattern of the development of classification may have counterparts in other groups of animals.

Indifference to the classification of the Pelecypoda began in 1913 and has continued for 40 years since. As a result, lack of knowledge of the basic works on the subject is continually being exhibited. One solution to our present state of stagnation is to reexamine the "classics" on pelecypod classification—papers by Neumayr, Dall, Pelseneer, Bernard, Jackson, and Douvillé. Each classification and set of facts on morphology, embryology (including growth stages of the shell), and paleontology should be thoroughly studied and the evidence evaluated. (Douvillé's classification might have been more widely accepted if he had assigned definite categories for his three-fold division of the Pelecypoda.) Incorrect data and conclusions should be deleted.

3. Little or no attention is paid to phylogeny in classification even when the evidence is clear and the author is aware of it.

This has led to serious errors in classification from the standpoint of practical morphology as well as phylogeny. For the past 40 years work on phylogeny has been considered relatively unimportant and unrewarding; however, at the ordinal level of pelecypod classification a careful analysis and synthesis of the classical work on pelecypods is our first need. Further work is needed on pelecypod morphology and shell structure, including more anatomical work on the soft parts. Further studies on the nepionic and later stages of the shell are also needed. The greatest lack, and probably the most fruitful line of investigation, is careful work on Triassic and Paleozoic pelecypods, for this work would lead to a better understanding of the relations of the various major groups of pelecypods.

THE SUPERFAMILY, FAMILY, SUBFAMILY

The superfamilies, families, and subfamilies have been undergoing some changes in number and scope within the past quarter of a century. The changes have been brought about slowly by the great increase in number of proposed genera and subgenera. The result has been for malacologists to group genera into new subfamilies, families, and superfamilies by redefining and restricting them. Two examples of this occurrence should show the involved problems.

Frizzell (1936) raised the family Veneridae to the rank of a superfamily and excluded the petricolaceans and glaucomyaceans from the Veneracea. The superfamily was then subdivided into nine families, and two of the families were further subdivided into subfamilies. Since 1936 other workers have erected more genera and subgenera of veneraceans, and the total is now about 200.

Recently Keen (1951) downgraded the Veneracea to the rank of a family, in which eleven subfamilies were included. In a more recent paper Tremlett (1953) followed Keen's classification and made the following comments (p. 1):

> D. L. Frizzell (1936), in one of the most recent works on this group, has suggested that they should be regarded as a superfamily Veneracea, with the same limits approximately as the family Veneridae as the term was used by Dall (1903), Jukes-Browne (1914), Palmer (1927), and others. I cannot see the advantage in raising the status of the group which is thereby separated from the closely related Petricolidae, and also from the Oncophoridae which are probably related to it; furthermore it unnecessarily increases the number of superfamilies. Even though the Veneridae are one of the largest families of pelecypods, the characters defining it are of about the same importance as those defining other families. Frizzell's families obviously have close similarities, and I prefer to regard them as subfamilies and retain the term Veneridae in its old sense.

The 11 subfamilies included by Keen in the Veneridae do not all have the same morphologic distinctness. How can these subfamilies be grouped to show the relationships? One solution that has been adopted is the one taken by Frizzell. Certainly the commonly used categories are available, and to raise the rank of several of the larger pelecypod families to the rank of superfamily would not create chaos in the classification. This course of action would probably be most acceptable to the malacologists and paleontologists. However, another solution is possible, if, as Tremlett claims, the morphologic characters defining the Veneridae are equal to, or of the same importance as, the morphologic characters defining other pelecypod families. This solution is to insert additional categories between the subfamily and the genus—for examples, the categories tribe and subtribe. The entomologists have done this for classifying many of the large families of insects.

Three ways of classifying a part of the veneraceans are shown on Table 1.

To add to the difficulties of an already large family, there are undoubtedly some aberrant groups which are venerids or veneraceans. I have considered the genus *Euloxa* a veneracean; but in order to fit it into the classification, I used Frizzell's arrangement, considered the Chionidae as a family, and subdivided the Chionidae into two subfamilies—the Chioninae and Euloxinae (Nicol, 1953, p. 60). This type of problem was also encountered in the genus *Pliocardia*. Once again I (1953a) used Frizzell's classification in order to show the systematic position of the genus. In each of these cases the only other reasonable solution would have been to create a category, such as tribe, between the subfamily and the genus.

It is true that some of the pelecypod genera and families have been split unreasonably (e.g., the genus *Inoceramus*); but the veneraceans do not appear to have received such disproportionate treatment, at least at the generic level, and Keen disagrees not with the number of groups designated by Frizzell, but with the rank to which he assigns them.

Furthermore, one of Tremlett's main objections to Frizzell's classification—namely that the morphologic characters defining the Veneridae are of about the same importance as those defining other families—apparently overlooks the fact that much of our classification of the pelecypods is based on the size of the group in question rather than on morphologic differentiation. For example, on the basis of morphologic characters the Cretaceous genera *Pseudocucullaea* and *Lopatinia* are quite distinct from all other prionodont genera; but, as they have few

TABLE 1.—THREE WAYS OF CLASSIFYING A PART OF THE VENERACEANS.

Frizzell, 1936	Keen, 1951	Another proposed solution
Superfamily Veneracea	Family Veneridae	Family Veneridae
Family Meretrecidae	Subfamily Meretrecinae	Subfamily Meretrecinae
Subfamily Meretrecinae	Subfamily Pitarinae	Tribe Meretrecini
Subfamily Pitarinae		Tribe Pitarini

species, they have not been placed in a separate subfamily or family. The Glycymeridae, on the other hand, although no more distinct morphologically than *Pseudocucullaea* or *Lopatinia*, have approximately 700 described species, ranging from the Cretaceous to the Recent, and have therefore been classified as a family. Although I do not assert that rank should be based upon size, it is nevertheless true that in many cases size has apparently been the decisive factor, and Tremlett's attitude is not realistic.

However, my objection to the ideas of Keen and Tremlett is not primarily that the rank should be Veneracea rather than Veneridae, but that their classification does not allow for enough categories to show adequately the relationships among the 200 genera and subgenera of the group.

A comparable situation is present in the arcaceans. The latest classification (Frizzell, 1946, p. 41) raises the rank of the family Arcidae to a superfamily, in which two families are included, the Arcidae and the Noetiidae. Of these, the first is subdivided into three subfamilies, and the second into two subfamilies. If Frizzell's arrangement is compared with the conservative arrangement of Reinhart (1935, pp. 11–12), one is astounded. Reinhart divides the Arcidae into three subfamilies—Arcinae, Anadarinae, and Noetiinae. The subfamily Litharcinae of Frizzell is relegated to the rank of a subgenus of *Arca* by Reinhart. Although I have found no published objection to Frizzell's arrangement of the Arcacea, objections similar to those of his classification of the Veneracea could, and probably will, be raised in the future. My preference for Frizzell's treatment of both the veneraceans and the arcaceans over more conservative classifications is that it has more categories in which to show more morphologic and phylogenetic relationships. Whether all the relationships as shown by Frizzell's classifications are correct or not is a matter to be investigated further.

Blackwelder (personal communication) has suggested to me the most objective and probably only satisfactory way of solving the type of problem exemplified by the Veneridae versus the Veneracea and the Arcidae versus the Arcacea. The genera of the family or superfamily being studied should be examined for morphologic similarities and inferred phylogenies. These genera can then be grouped, and the groups can likewise be grouped in a series of ascending categories. The number of categories necessary in order to show the relationships can then be ascertained. What category should be used for the group as a whole should be based primarily on what has been used in related groups; and when the rank of the group studied is decided, then the various subdivisions of the group should fall into place. In the case of the pelecypods this will not be easy because the entire classification at the familial levels is nebulous. However, much progress could be made if these problems were approached in as objective a manner as possible. Such studies would undoubtedly result in many major changes in the classification of the pelecypods above the generic level.

There has been a tendency to redefine, restrict, and propose more subfamilies, families, and superfamilies, apparently as a result of the rapid increase in the number of proposed genera and subgenera of pelecypods. This tendency has met with some opposition, but some of the objections to creating more families or raising the various groups to higher categories seem to be ill-founded. As MacNeil (1938, p. 1) stated:

> With our increasing knowledge of the structure and phylogeny of the Pelecypoda it becomes more and more obvious that their supergeneric classification is short of satisfaction, the principal defect being that not enough groups of high ordinal rank have been recognized.

Recognition of more groups of high ordinal rank would undoubtedly alleviate many of our present problems of pelecypod classification. Another solution might be to create categories for groups between the generic and subfamily levels as the entomologists, for example, have done.

To improve the classification more work is needed at the genus and family levels, and it should include a careful analysis of all morphologic, embryologic, chronogenetic, and geographic data. Many of the basic

data are in the literature—but careful analysis and synthesis of the data are needed to ascertain phylogenetic relationships.

SOME BASIC PELECYPOD LITERATURE

A thorough understanding of the following references is necessary as a starting point for a classification of the Pelecypoda. This list is not intended to be complete, but it should form a good basis for the student who is interested in this group of mollusks.

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